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Preservation of Wood in Damp and Wet Situations. By H. W. Lewis, University of Michigan.

GRADUATING THESIS.

No introductory apology for the theme of this paper is judged necessary. A few plain statements will show that the subject is one of vast though unheeded importance.

The annual drain which is exhausting our forests is startling when we remember the vast areas of our country utterly destitute of timber—when we learn, for instance, that "upon the 55,000 square miles of Illinois, there grows not a single pine large enough from which to fashion a board.* Statistics show that, in 1865, above 5,000,000,000 feet of lumber, 2,000,000,000 of shingles, and 900,000,000 pieces of lath were sold in Chicago alone.† Michigan and Wisconsin almost entirely supply that market. 6000 feet of pine lumber per acre is an average yield.‡ No formal calculation is necessary to show us that, with the present demand, a single generation will exhaust the supply those States can afford.

* Hunt's *Merchant's Mag.*, Feb., 1866, page 105.

† Lumber, 5,089,033,033 feet; shingles, 3,560,093,212; lath pieces, 938,297,743. —Hunt's *Merchant's Mag.*

‡ "An average estimate of the product of lumber of all the pine lands in the State is 6000 feet to the acre. Some sections will overrun, some fall short, of this amount." * * * "Seven years will exhaust all the pine lumber within five miles of any of the navigable rivers."—*The Pine Lands and Lumber Trade of Michigan*, page 4.

But the consumption increases in a rapid ratio. It has already raised the prices. Clear lumber sold for $18 per thousand in 1855, for $24 per thousand in 1860, and for $45 per thousand in 1865.* And following close on Chicago, in this trade, are Albany and Pittsburgh.†

Improvidence will soon, we fear, make us as dependent on foreign supplies of timber as is England, who has already granted numerous patents for processes promoting the durability of the lumber every enlightened nation must have.

Shall we employ those processes whose utility experience has demonstrated? Self-interest returns but one answer. But in American railway management, self-interest seems to be disregarded. While the average life of English railway sleepers is fifteen years, that of American sleepers is only seven years.‡ Allowing 2112 sleepers per mile, at fifty cents each,§ $1056 per mile of American railroad *decays* every seven years. Thoroughly impregnate those sleepers with sulphate of copper, at a cost of five cents each, and they would last twice as long. Thus would be effected a saving of $880 per mile‖ in the seven years, on sleepers alone. In the United States are 33,908·6 miles of railroad.¶ The whole saving on these lines would be $29,839,568, or upwards of $4,262,795 per annum.

Again, English engineers deride American wooden railway bridges. Eight years is their average duration.** Creosote them and they are good for double or treble that time.†† For ordinary railroad purposes they cost $40 per linear foot.‡‡ The use of Bethell's process would effect a great saving on such a line as the Grand Trunk Railway, whose wooden bridges measure 9355 feet upon the Montreal and Portland division alone.§§ Further illustrations of the importance of preserving timber from decay seems unnecessary. Let us proceed to the discussion of this desirable object.

In situations so free from moisture that we may practically call them dry, the durability of timber is almost unlimited. The roof of Westminster Hall is more than 450 years old. In Stirling Castle are carvings in oak, well preserved, over 300 years of age. Scotch fir

* Hunt's *Merchant's Mag.*, Feb., 1866, pages 106 and 107. † Ibid., p. 105.

‡ *New American Cyclopædia*, vol. xiii., page 734.

§ *Scientific American*, February 17, 1866. Also Col. Berrien's (Chief C. E. of M. C. R R.) estimate of their cost for the past two years on the "Michigan Central Railroad."

‖ Five cents, at seven per cent. compound interest, amounts, in seven years, to eight cents. 50 cents — 8 cents = 42 cents saved *on each sleeper* at the end of seven years. $0·42 × 2112 = $887·04 saved per mile in seven years.

¶ De Bow's *Review*, February, 1866, page 207.

** *Civil Engineer's Journal*, vol. xxiv., page 282.

†† "A properly constructed railway bridge of suitable materials may be fully relied on for twenty years."—*Journal Franklin Institute*, vol. xxxvi., page 1.

‡‡ *Civil Engineer's Journal*, vol. xxiv., page 282.

§§ *Journal Franklin Institute*

has been found in good condition after a known use of 300 years,* and the trusses of the roof of the Basilica of St. Paul, Rome, were sound and good, after 1000 years of service.† After these well attested examples of preservation, the further consideration of wood in this state seems unnecessary.

Wood constantly wet in fresh water is quite as durable. Piles were dug from the foundations of old Savoy Palace, in a perfectly sound state, after having been down 650 years. The piles of old London Bridge were found sound and perfect 800 years after they were driven.‡

While the acidity of bog-water retards decay, it seems to us that part of the preservative property attributed to the stagnant liquid§ should be ascribed to the salts of metals or alkaline earths held in solution, and deposited among the woody fibres.

In the above situations, the action of natural agents cannot be improved. But in certain other conditions, man must resort to preservative processes to secure permanence of structure. For convenience of discussion we have introduced the following classification:

1. When wood is damp we have to guard against dry rot.
2. When wood is alternately wet and dry we have to guard against wet rot.
3. When wood is constantly wet in sea-water we have to guard against teredo navalis and limnoria terebrans.

1. *Wood in Damp Situations.*—When unseasoned wood is surrounded by dead air, it very rapidly decays, fine fungous growths extending through every part. After the rot has begun, the mere contact of decayed and sound wood seems sufficient to ensure, by a catalytic action, its spread through the latter. This has probably led some observers to their conclusions, that the accompanying parasitic plants, Merulius lachrymans (or L. vastator) and Polyporus hydridus, cause the decay. But the highest authorities now regard these growths as accessory, and beginning only after a suitable habitat has been prepared for them.‖ Thus the fungus acts the part of a scavenger and converts corrupt matter into new forms of life. The presence in the timber of the fungi spores is easily explained. The researches of Pasteur show that atmospheric dust is filled with minute germs of various species of animals and plants, ready to develop as soon as they fall into a congenial locality. He concludes that all fermentation is caused by the germination of such infinitesimal spores.¶ That they elude observation, does not seem strange, when we consider that some

* The *Builder*, vol. ii., page 638. † Ibid., p. 616. ‡ Ibid., p. 616.

§ *Civil Engineer's Journal*, vol. xxi.

‖ "There is no reason to believe that fungi can make use of organic compounds in any other than a state of decomposition."—Carpenter's *Comp. Physiology*, page 165. (See also *Encyclopædia Britanica* on this subject.)

¶ "Powders suspended in the air are the exclusive origin, the first and necessary condition of life in infusions, in putrecible bodies, and in liquids capable of undergoing fermentation."—See translation of Pasteur's experiments in vol. xxxii., page 9 of *American Journal of Science*.

infusoria are only $\frac{1}{24000}$ of an inch in length.* Admitting that they are only ten times the linear dimensions of their germs, the latter will be $\frac{1}{2400000}$ of an inch long. But with the best microscopes we cannot perceive objects measuring less than $\frac{1}{800000}$ of an inch. These germs might find their way into the growing plant through both roots and leaves. The whole tree is thus filled with the seeds of decay, awaiting suitable conditions to spring into growing organisms. The prolonged vitality of spores, made necessary by this theory, cannot be a serious objection, when we remember the vigor of the "mummy wheat," and the unknown plants which start from the earth raised from deep excavations. Indeed, time, even when measured by centuries, seems hardly to affect the vitality of vegetable germs.

But what prepares timber for the germination of the fungi spores? Probably fermentation of the juices and semi-solids of the moist wood. For fermentation, five conditions are necessary,† viz: 1. Presence of water. 2. Temperature from 40° to 110° Fahr. 3. Presence of a ferment. 4. Presence of a fermentable body. 5. Exposure to the atmosphere.

Three of these conditions almost always prevail. Very rarely, if ever, can we maintain the temperature of any timber construction below 40° Fahr., or above 110° Fahr. Probably countless numbers of ferment spores are annually absorbed into the fluids of the smallest sapling. Completely excluding any construction above earth and water, from the atmosphere, is practically impossible. The two remaining conditions we can generally prevent.

1. We can remove the water by thorough seasoning, and in damp situations we can practically prevent its return by ventilation or resinous coatings.

Examples of remarkable durability of wood have been cited. With equal care in selecting and preparing the lumber, modern constructions might last as long. But while the wood of those old edifices was drying through years of preparation, the timber of modern constructions is translated from the primitive forest into a painted and varnished city dwelling in less than a single year's time. No wonder that in a very few decades, the whole structure is unsafe,‡ and that an odor of decay makes the mouldering rooms untenable.

* "Some infusoria are not more than $\frac{1}{24000}$ of an inch in diameter, and if we suppose the spores to be only $\frac{1}{10}$ of the parent's linear dimensions, there must be an incalculable amount of germs no larger than $\frac{1}{240000}$ of an inch in diameter. Since, according to Sullivant and Wormley, vision, with the most powerful microscopes, is limited to objects of $\frac{1}{80000}$ of an inch, we need not be surprised that we do not always see the floating germs of animals and plants."—Note by the translator of Pasteur's researches, *American Journal of Science*, vol. xxxii., page 9.

† Notes on Prof. A. B. Prescott's *Lectures on Organic Chemistry* in the University.

‡ For an account of the rapid destruction of the floors and joists of the Church of the Holy Trinity, Cork, Ireland, by dry rot, see *Civil Engineer's Journal*, vol. xii., page 303. For an account of the decay of floors, studs, &c., in a dwelling, see the *Builder*, vol. vi., page 34.

"In some of the mines in France the props seldom last more than fifteen months." *Annales des Mines.*

Thorough ventilation is indispensable to the preservation of even well-seasoned *naked* wood in damp localities. The rapid decomposition of sills, sleepers, and lower floors is not surprising where neither wall-gratings nor ventilating flues carry off the moisture rising from the earth, or foul gases evolved in the decay of the surface mould. In the close air of cellers, and beneath buildings, the experiments of Pasteur detected the largest per centage of fungi spores. Remove the earth to the foot of the foundation, and fill in the cavity with dry sand, plaster-rubbish, &c., or lay down a thick stratum of cement to exclude the water, and provide for a complete circulation of air, and lower floors will last nearly as long as upper ones.*

Various expedients have been resorted to, in order to hasten the seasoning process. Mr. P. W. Barlow's patent† provided for exhausting the air from one end of the log, while one or more atmospheres press upon the other end. This artificial aërial circulation through the wood is prolonged at pleasure. However excellent in theory, this process is not practicable. By another method, the smoke and hot gases of a coal fire are conveyed among the lumber, placed in a strong draft. Some writers recommend the removal of the bark one season before felling the tree. All good authorities agree *that the cutting should take place in the winter season.*‡

An impervious covering upon undried timber is very detrimental, for by it all the elements of decay are retained and compelled to do their destroying work. The folly of oiling, painting, or charring the surface of unseasoned wood is therefore evident. Owing to this blunder alone, it is no unusual thing to find the painted wood-work of older buildings completely rotted away, while the contiguous naked parts are perfectly sound.

In concluding this part of the subject we may say, *thoroughly season your lumber, afterwards cover it with varnish, paint, or pitch, or maintain around it a constant and thorough circulation of air.*

2. We can remove the fermentable body, or chemically change its nature.

Woody fibre consists chiefly of cellulose and lignine. The former is very durable, and the latter moulders away but slowly, when exposed to air and moisture. But permeating through these, and increasing from the heart to the alburnum, are nitrogenous substances of the sap and immature wood, mostly vegetable albumen. These are the fermentable bodies we desire to remove or change. A patented process has been proposed to wash out the albumen by water flowing in at one end of the log while a vacuum was produced at the other. Theoretically satisfactory, this method does not seem to have been adopted. Boiling and steaming partly remove the ferment spores, but *may not*

* The *Builder*, vol. xi., page 46. † *Civ. Eng. Jour.*, vol. xix., p. 422.

‡ Experiments detailed in the *Cosmos* show conclusively that winter-cut pine is stronger and more durable than that cut at any other season of the year.—*Ann. Sc. Discovery* for 1861, page 346.

"Oak trees felled in the winter make the best timber."—The *Builder*, 1859, page 138.

destroy the vitality of those remaining. For, according to Milve-Edwards, he has seen tardigrades resist the prolonged action of a temperature of 248° Fahr., and has known them to survive a temperature of 284° Fahr.* That low forms of vegetation are fully as tenacious of life cannot be doubted.

Boiling and steaming also coagulate the albumen at 140° Fahr. Although coagulated albumen is insoluble in water, the water of solution is, by this heating process, sealed up in the wood, and the cohesion of the latter is said to be diminished.

Albumen is also coagulated by sulphate of copper, pyrolignite of iron, chloride of mercury, chloride of zinc, &c. Some of the compounds thus formed are albuminates of the metallic oxides. Probably this is the reason why some of those salts are such excellent preservatives. But the researches of Kœnig† show that, when blue vitriol is employed, a certain portion of basic sulphate of copper remains combined in the pores of the wood so that water will not wash it out. The most resinous woods retain the most of the basic salt. Impregnated woods also contained, he found, less nitrogen than natural. It is even possible, he states, to remove all the azotized compounds by long immersion in the sulphate solution. The albuminous substances first precipitated by the solution, are redissolved by excess, as in case of concentrated sulphuric and muriatic acids.‡ The operation of such solutions should, therefore, be one of lixiviation. Knœig hopes, similarly, to explain the action of the chlorides. A recent experiment on animal albumen by Professor Prescott, shows that its precipitate by the chloride of mercury, *is* also soluble in excess of the chloride solution. From this we may conclude that the antiseptic qualities of the chlorides depend, at least partly, on their dissolving out the albumen.

But could all the nitrogenous substances be removed, thereby preventing fermentation, the cellulose and lignine of unprotected wood would slowly decompose. Hence the salt used should act on those substances also. According to good authority, sulphate of copper has this action. M. Weltz maintains that, after a time, the sulphuric acid leaves the base, and acting upon the timber, carbonizes it. He has seen the props in a mine, opened 1800 years ago, charred by the free acid thus eliminated and in a perfect state of preservation, while their surfaces were covered with metallic copper in regulus.§

The use of corrosive sublimate was patented by Mr. Kyan in 1832; that of chloride of zinc by Burnett in 1838. M. Boucherie has used

* "Although, in ordinary cases, the death of animals takes place when the temperature is sufficiently high to coagulate the hydrated albumen in their tissues, we know that this is not always so in case of those previously dried. I have seen tardigrades resist the very prolonged action of a stove whose temperature stood at 120° C., and in the researches of Mr. Doyère, the heat was carried to 140° C., (284° F.,) without death ensuing from the heat."—Mr. Edwards on "Spontaneous Generation."—*Am. Jour. Science*, vol. xxvii., page 405.

† *Am. Jour. Science*, 2d series, vol. xxxii., page 274.

‡ *Brande and Taylor's Chemistry*, p. 634.

§ *Annual Sc. Discov.*, 1865, p. 51.

solutions of blue vitriol and pyrolignite of iron. Easy impregnation of the wood is the great merit of his method.

Each process has in turn excited the most extravagant hopes, and neither has justified a tithe of the expectations formed. While "Kyanizing," "Burnettizing," or the use of any salt whatever, has not prevented the ravages of teredo navalis or limnoria terebrans, each of the processes named improves the durability of wood exposed to dampness. Each is, therefore, worthy of explanation here.

Kyan's specified solution* was one pound of chloride of mercury to four gallons of water. Long immersion in the liquid in open vats, or great pressure upon both solution and wood, in large wrought iron tanks, is necessary for the complete injection of the liquid. The durability of well kyanized timber has been proved, but the expensiveness of the operation will long forbid its extensive adoption.

For "Burnettizing,"† a solution of chloride of zinc—one pound of salt to ten gallons of water—is forced into the wood under a pressure of 150 lbs. per square inch.

Boucherie employs a solution‡ of sulphate of copper one pound to water twelve and a half gallons, or pyrolignite of iron one gallon to water six gallons. He encloses one end of the green stick in a close fitting collar, to which is attached an impervious bag communicating through a flexible tube with an elevated reservoir containing the salt liquid. Hydrostatic pressure soon expels the sap at the opposite end of the log. When the solution makes its appearance also, the process is completed.

He finds the fluid will pass *along* the grain—a distance of 12 feet—under a lower pressure than is required to force it *across* the grain—three-fourths of an inch. The operation is performed upon green timber with the greatest facility.§

* *Civil Engineer's Journal*, vol. v., page 202. † Ibid., vol. xiv., p. 471.

‡ *Civil Engineer's Journal*, vol. xx., p. 405.

§ As a modification of this method he also cut a channel in the wood throughout the circumference of the tree, fitted a reservoir thereunto, and poured in the liquid. The vital forces speedily disseminated the solution throughout the tree.

(To be continued.)

Cantor Lectures.—On Submarine Telegraphy. By Fleeming Jenkin, Esq., C.E., F.R.S.

From the London Journal of the Society of Arts, No. 690.

(Continued from page 163.)

LECTURE II.

Shallow and Deep Sea Cables.—The lecturer first alluded to the omission from the first lecture of any mention of the new insulators —balata, Parkesine, collodion, Mr. Mackintosh's material, and others. This omission was an oversight, due possibly to the fact that, as he

has been unable to procure a specimen of any one of these materials for examination, he had formed no opinion as to their merits. The value of a new, good, and cheap insulator would be very great. The following is an abstract of the second lecture, under the heads in the syllabus:

1. *Serving and Worming.*—Strands of hemp or jute are commonly laid or spun round the insulated core to serve as a pad or protection against pressure from the iron wires afterwards applied, and also, in some cases, to form a larger heart, allowing larger and more wires to be applied than could lie round the small insulated wire. This covering of hemp or jute is called the "serving" of the cable. When several insulated wires, to transmit distinct simultaneous messages, are included in one cable, as for short distances is frequently the case, these insulated wires are laid in a long strand, with hemp between them, to form a circular core. This hemp is called the "worming." The worming and serving were formerly tarred for their preservation against decay in water; but Mr. Willoughby Smith showed that the tar temporarily mended small faults of insulation, and might, therefore, conceal an accidental injury to the core; but tar was not so good an insulator as permanently to mend the fault, so that the tar might lead to the submersion of a fault which would otherwise have been discovered and repaired before submersion. To avoid this risk tanned hemp is now used, and is often applied wet, to increase the chance of at once detecting any accidental injury to the gutta-percha. Hemp under wires is remarkably durable, and jute also answers well as a cheaper substitute. When hemp is exposed in water it soon decays, and jute decays still more rapidly; both are liable to be eaten by animals where exposed, but not where covered by iron. A specimen was shown where a small quantity of hemp exposed by a kink, at a depth of 800 fathoms in the Mediterranean, had been attacked by a species of teredo; the part immediately adjacent, covered by iron wire, was intact. These animals exist in the Mediterranean even in depths of 1200 and 1600 fathoms. In applying the covering, care must be taken that the insulated wire be not overstrained; the simplicity of the work has sometimes led to the use of imperfect machines which might cut the gutta-percha, and to the employment of boys too young to be careful.

2. *Iron Sheathing.*—The served core is commonly protected by iron wires laid round and round in a long helix, and abutting one against another, so as to present the appearance of a simple iron wire rope. This sheathing is frequently called a spiral covering, but the wires lie in a helix, not a spiral, which is a curve like that formed by a watch-spring, not that formed by a corkscrew. There is a popular impression that this form of cable must necessarily be very easily extended or stretched; but this impression is wholly erroneous. The single helix stretches by becoming more nearly a straight line, and by gradually closing so as to include a smaller and smaller cylindrical space; if this closing be prevented, (for instance, if the wire be wrapped round a solid core,) the helix will not stretch more than a solid wire; the closing is prevented in the ordinary cables by the arrangement of the outer wires,

which abut, each upon its neighbor, so that a cross-section of the cable shows a compact iron ring. The tube formed by the wires cannot diminish in diameter, and, consequently, the helix cannot stretch more than a solid wire. This is proved by the experiments of Messrs. Gisborne, Forde, and Siemens in the "Report of the Joint Committee on Submarine Cables," 1861. Some extracts from their results are given in Table IV. The stretch of the Atlantic, Red Sea, and Malta-Alexandria cables before breaking is, as will be seen, hardly more than the stretch of a single iron wire (part II., Table IV.); the slight excess is owing to a slight diminution in the diameter of the cable due to the more perfect closing of the wires one upon another when the strain is applied. Owing to the perfect iron ring formed by the wires, the inner core is not sensibly compressed. A helix may elongate by untwisting as well as by closing in the manner described, and sometimes this defect has been alleged as the only serious one. The total elongation which could arise from this cause is the difference of length between the wire as it lies round the cable and when stretched out straight. This is about 1½ per cent. in the Malta-Alexandria cable; but no sensible untwisting ever does occur. About forty or fifty turns are, at most, taken out per mile, and this would elongate such a cable about eighteen inches per mile, or about 0·03 per cent. When cables are recovered from great depths, no sensible change in the lay is found to have taken place. It cannot be seen that they have in any way been untwisted or stretched. Specimens of cable thus recovered were exhibited, and the following experiments shown to enforce the reasoning: First, half a ton was hung on a light iron cable of the usual form, and it was seen that no stretch occurred, although less than half the weight would have stretched the core inside 20 per cent., and finally have broken it. This proved that the strain was really born by the rigid helical iron wires outside, not by the core inside. Secondly, weights were hung on a single wire, outside a core of hemp and gutta-percha; this stretched a very little. Lastly, an experiment was tried which, to all appearance, resembled the first; but on the weights being taken off, the rope was bent and opened, and shown to consist of a mere hollow shell of iron wires, without any core whatever inside for eighteen inches of its length. This proved that the iron wires do not press injuriously on the core. In all these experiments the rope was free to untwist, but did not do so sensibly. The experiments were simple illustrations of facts well known to all practically acquainted with telegraphic cables. It may therefore be assumed that the common form of cable is not liable to stretch, but another defect—the liability to kink—has been urged against it. A kink is a loop drawn tight, or a twist in a rope concentrated at one point. Specimens of kinks were shown. A kink may be produced in any form of cable, with or without helical covering, inasmuch as a loop or twist may be produced in any form by mismanagement. A rope coiled round a drum, with one side out, may be wound off and rolled round another drum, or paid out into the sea, without receiving any twist, but if, by mismanagement, the rope were pulled off the end of the drum, it would be twisted or kinked. Simi-

TABLE IV.—*Strength and Elongation of Cables and Materials.*

PART I.—*Cables.*

(The Specifications are given at the end of the Abstract of this Lecture.)

CABLES.	Breaking strain in cwts.	Corresponding length in water. Fathoms.	Per cent. of elongation, with one-half breaking weight, per cent.	Per cent. of elongation, with breaking weight, per cent.	Weight per knot in air. Cwts.	Weight per knot in water. Cwts.	REMARKS AND AUTHORITIES.
First Atlantic.....	80	4,979	0·24	0·8	21·70	16·30	Report of Joint Committee, App. 10.
Red Sea.....	65 to 87.5	3,806 to 5,112	0·16 to 0·34	0·56 to 1·16	21	17·30	Do. do. do.
Malta-Alexandria	147 " 157	4,565 " 4,874	0·2 " 0·36	0·5 " 0·86	42·70	32 73	Do. do. do.
Second Atlantic.....	154	11,000	.....	2·57 " 4·65	35·75	14·0	Unpublished experiments by Mr. Fairbairn.
Steel and hemp-coated, Gibraltar.....	102·5 " 147·5	7,928 "11,407	0·62 " 1·24	1·87 " 4·06	25·47	13·11	Report of Joint Committee, App. 10.
Iron and hemp-coated	67·5 " 75	5,346 " 6,000	0·26 " 0·77	1·80 " 3·10	24·87	12 65	Do. do. do.
Siemens' copper-covered cable.....	50	6,250	.....	0·8	18·61	7·97	Mr. C. W. Siemens' unpublished information.
Allan's cable.....	18·37	7,500	.....	1·0	8 0	2·5	Mr. Allan's unpubli-hed information.
Ratan and stretched hemp.....	15·75	8,500	0·52	1·56	7·73	1·86	Messrs Forde and Jenkin's unpublished information.

PART II.—*Materials.*

MATERIALS.	Breaking strain in cwts.	Corresponding length in water. Fathoms.	Per cent. of elongation with one-half breaking weight, per cent.	Per cent. of elongation with breaking weight, per cent.	Weight per knot in air. Cwt.	Weight per knot in water. Cwt.	REMARKS.
Copper strand, Malta-Alex.	5·75	.....	0·22	8·5	3·57	3·125	Report of Joint Committee, App. 10.
Core, Malta-Alex.....	5·75 to 7·5	2,360 to 2,826	0·28	22 to 25	7·15	3·36	Do. do. do.
*Iron wire, 0·079 in....	4·18 " 4·5	5,600 " 6,040	0·12 to 0·18	0·46 " 0·72	96 lbs.	83·5	Do. do. do.
*Steel wire, 0·079 in....	8·00 " 8·50	10,600 " 11,200	0·28 " 0·34	1·00 " 1·80	97 lbs.	84 7	Do. do. do.
Hemp and iron.....	5·00 " 7·43	.....	0·16 " 0·32	1·04 " 2·46	141 lbs.	.....	Do. do. do.
Steel and hemp	10·87 " 11·75	.....	0·37 " 0·51	2·28 " 2·70	142 lbs.	.....	Do. do. do.
Hemp alone.....	2·87	.....	.....	.....	45 lbs.	.....	Do. do. do.

* Other specimens of iron and steel would be found to stretch differently. Some iron and some steel would stretch considerably more, and very hard specimens would stretch less. The above results seem to be taken from fair samples.

larly, if coiled in a tank, with one side always uppermost, although apparently without twist, it would be twisted or kinked when pulled straight out of the hold. In practice, these plans are not adopted; the cable is carried down into the tanks from a drum with one side always turned in one direction. Let one side of a straight cable be marked black, and let it be coiled into the hold, so that the black side shall always be north; then this black mark will, on the north side of the tank, be turned from the centre, at the south side to the centre, at the east and west side it will be uppermost and undermost, respectively. The rope thus coiled in will have one twist in it for every turn round the tank. In a spun rope, this twist will twist the rope tighter, or untwist it, according to the direction in which the rope is coiled; but in either case, when the rope is drawn out of the coil it comes out as it was put in—straight and without twist. The extra turn or twist is caused by coiling, and removed by uncoiling. There is one simple, universal, and sufficient rule to prevent the occurrence of a permanent twist. The cable must be taken out of the tank or off the drum, in the same manner as it is put in or on; the opposite course will always put a permanent twist into a cable, and this twist, concentrated at one point, produces a kink. These points were illustrated by elementary experiments with a piece of india rubber tubing to represent a cable. One side of the tube was painted so that a twist could readily be seen. When a cable is properly coiled in the tank, it is possible, by a severe jerk, so to mismanage the uncoiling as not to take out the twist regularly, and kinks have thus been caused by several turns being caught up at once out of the hold. This now very seldom happens. Not one kink occurred during the paying out of the Malta-Alexandria and Persian Gulf cables, or during the late Atlantic expedition, in all about 3500 knots. Even when a kink does occur, it seldom injures the cable. A specimen was shown, cut from the Dover and Calais cable, containing six insulated wires, through which, kinked as they were, messages had for years been transmitted between England and France. The common form of cables affords a good mechanical protection against injury.

3. *Iron and Steel Wire.*—The tensile strength of a cable is the sum of the strength of the wires composing it. A cable covered with good iron should bear a strain equal to two tons per pound of iron wire per fathom. Thus, a cable with 3750 lbs. of iron per knot, or 3·75 lbs. per fathom in the sheathing, should bear 7½ tons. This rule corresponds to a strength of about 41 tons per square inch. The larger gauges and inferior qualities of iron cannot be expected to bear so high a strain as this. Best best is the quality most usually specified, but charcoal wire seems to be more permanent than the inferior brands. The wire should in no case be hard or brittle. Bright wire is generally used for the smaller gauges, and black wire for the larger gauges, unless the wire be galvanized. Table V. gives the relative weights per knot of the different gauges, according to Messrs. Johnson, of Manchester. The weight of a wire per knot in pounds is nearly equal to the square of the diameter in inches, multiplied by 16,100, or say $16{,}100d^2$.

The wires are joined by welding and the cables by splicing. These operations require no special description. Welds should not be allowed in two wires of a cable at the same point, or near the same point.

TABLE V.—*Showing weights of iron wire of different gauges.*

B. W. G.	lbs. per knot.
00	2066·68
0	1716·48
1	1393·92
2	1212·20
3	1048·32
4	872·80
5	748·80
6	622·08
7	529·92
8	449·28
9	368·64
10	305·82
11	241·99
12	184·32
13	144·00
14	109·44
15	86·40
16	65·66
17	50·68
18	39·16

4. *Sheathing Machines.*—These apply the wire with a constant tension and so as not to twist it, keeping one side always uppermost, so that if it faces the core below the cable it will be turned away from the core at the top. To do this each bobbin holding the wire moves parallel to itself. The effect of this arrangement was experimentally shown with the india rubber tube to represent a wire. The effect of the other arrangement, in which the bobbin moves round the cable fast on a disc, as the arm of a wheel moves round the nave, or as the moon round the earth, was also shown. This arrangement twists the wire. Cables made with twisted wire are weaker and less manageable than those made with untwisted wire.

5. *Permanency of Cables.*—The wires of cables may rust or be chafed through on rocks, or be eaten through by some chemical action other than simple rusting, or they may be broken by anchors. Any motion in the water round a cable much accelerates the rusting away, and chafing depends wholly on this cause. In some bottoms, even in still water or great depths, decay does occur very rapidly, and this must be due to some other cause than simple rusting. Large wires are the natural protection to injury from the causes enumerated. Galvanizing also protects the wires from simple rust. In some situations the simple unprotected wires remain wonderfully unaltered, but protection where possible should always be given. Bright and Clark's silicated bituminous compound applied over the wires affords the best protection yet known. The Persian Gulf cable is coated with it from end to end. To ensure permanency, cables in shallow seas were now laid weighing as much as ten tons per mile, with shore ends weighing nearly twenty tons to resist anchors (*vide* England-Holland cable, Appendix). Many

heavy shore ends were covered with strands of wire instead of simple wires. Mr. Siemens proposed to apply a covering of hemp outside the iron wires and to wrap this round with a zinc armor.

(To be continued.)

For the Journal of the Franklin Institute.

Pile Driving. By CHAS. H. HASWELL, Civil and Marine Eng., N.Y.

The effect of the blow of a ram, or monkey, of a pile-driver, is as the square of its velocity, but the impact is not to be estimated directly by this rule, as the degree and extent of the yielding of the pile materially affects it. The rule, therefore, is of value in application only as a means of comparison.

By my experiments in 1852, to determine the *dynamical* effect of a falling body, it appeared that whilst the effect was directly as the velocity, it was far greater than that usually estimated by the formula $v = \sqrt{s\,2\,g}$, which, for a weight of 1 lb. falling 2 feet, would be 11·34, giving a momentum of 11·34 ft. lbs., whereas by the effect shown by the following record of actual observation, it would be $v \text{ w } 4{\cdot}426 =$ 50 lbs.

Results of experiments made to determine the dynamical effect of bodies falling freely, 1852.

Weight of falling body, avoirdupois.	Space fallen through.	Velocity acquired at end of fall, per second.	Effect as indicated by instrument.
lbs.	feet.	feet.	lbs.
·5	·5	5·67	12·5
·5	1·	8·02	17·75
·5	2·	11·34	25·
·5	3·	13·89	31·
·5	4·	16·04	36·
·5	5·	17·93	40·
1·	·5	5·67	25·
1·	1·	8·02	35·5
1·	2·	11·34	50·
1·5	·5	5·67	37·
1·5	1·	8·02	53·
2·	·5	5·67	50·
2·	1·	8·02	71·5

Piles are distinguished according to their position and purpose; thus, *gauge piles* are driven to define the limit of the ground to be enclosed, or as guides to the permanent piling.

Sheet or *close piles* are driven between the gauge piles to form a continuous enclosure of the work.

The weight which is required of each pile to sustain should be computed as if it stood unsupported by any surrounding earth.

When the length of an oak pile does not exceed sixteen times its

diameter, it may be loaded permanently with a weight of 450 lbs. per square inch of its sectional area.

A heavy ram and a low fall is the most effective condition of operation of a pile driver, provided the height is such that the force of the blow will not be expended in merely overcoming the inertia of the pile, and, at the same time, not from such a height as to generate a velocity which will be expended in crushing the fibres of the head of the pile.

The *refusal* of a pile intended to support a weight of 13½ tons can be safely taken at ten blows of a ram of 1350 lbs., falling 12 feet, and depressing the pile four-fifths of an inch at each stroke.

Pneumatic Piles.—A hollow pile of cast iron, 2½ feet in diameter, was depressed into the Goodwin sands 33 feet 7 inches in 5½ hours.

Nasmyth's Steam Pile Hammer has driven a pile 14 inches square, and 18 feet in length, 15 feet into a coarse ground, imbedded in a strong clay, in 17 seconds, with 20 blows of the hammer, or monkey, making 70 strokes per minute.

By the extended observations of Brevet Major John Sanders, U.S. Engineers, he deduced the following rule whereby to estimate the weight that can be safely borne upon a pile: "As many times the weight of the ram, as the distance which the pile is sunk, the last blow is contained in the distance which the ram falls in making the blow, divided by 8," which, when reduced to a formula, becomes

$$\frac{(\text{R} \times h \div d)}{8} = \text{W},$$

R *representing the weight of the ram in pounds, h the height of the fall, and d the distance the pile is depressed by the blow, both in feet.*

Here, then, is obtained a formula whereby to compute the limit of operation of a driver, which is essentially all that is required.

Illustration.—A ram, weighing 3500 lbs., falling 3½ feet, depressed a pile 4·2 ins. Then,

$$\frac{3500 \times (42 \div 4{\cdot}2)}{8} = \frac{35000}{8} = 4375 \text{ lbs.},$$

the weight which the pile would bear with safety.

By the ordinary formula $\sqrt{v^2 g}$ W, $15 \times 3500 = 52{,}750$ lbs., the computed force; hence, assuming the rule of Major Sanders as a guide, $\frac{4375}{52{,}750} = {\cdot}0814$, which may be taken as the co-efficient whereby to reduce the momentum of a ram to the weight the pile can bear with safety.

Messrs. M. Scott and J. Robertson submitted to the Institution of Mechanical Engineers, London, 1857, a paper on the "Theory of Pile Driving," of which the following are the essential points, when briefly given, viz:

The object of the investigation of pile driving is not to determine to a fraction of an inch the distance a pile may be driven, and especially so, as the resistance offered by the earth, which is the most im-

portant element, cannot be correctly ascertained, but the object is to elicit the simple and general truths upon which the system depends.

Dr. Whewell deduced—

1. A slight increase in the hardness of the pile, or in the weight of the ram, will considerably increase the distance the pile may be driven.

2. The resistance being great, the lighter the pile the faster it may be driven.

3. The distance driven varies as the cube of the weight of the ram.

Although these deductions cannot be depended upon as exact under all circumstances, they give a tolerably correct indication, and are in accordance with those which may be arrived at by general reasoning. The complication in the original expressions arises from taking into consideration in the general question the weight and inertia of the pile. The weight of the pile bears so small proportion to the resistance of the earth, that it may be neglected; for a pile 25 feet in length and 1 foot square weighs about one-half a ton, and if the fall of a ram weighing one ton is 10 feet, and the distance driven by the blow is 2 inches, then the resistance of the earth will be to the weight of the ram as 120 inches to 2 inches; that is, it will be 60 tons, of which one-half a ton is the $\frac{1}{120}$ part, and may, therefore, be neglected.

To Compute the Space through which a Pile is Driven.

$\frac{R\,h}{C} = s$, C representing the resistance of the earth. Hence, by inversion,

To Compute the Co-efficient of the Resistance of the Earth.

$$\frac{R\,h}{s} = C.$$

Weisbach gives the following formula: The resistance of the bed of earth being constant, the mechanical effect expended in the penetration of the pile will be—

$$\frac{R^2\,h}{P + R\,s} = W.$$

Taking the elements of the preceding case, with the addition of the weight of the pile at 1500 lbs., the result would be—

$$\frac{3500^2 \times 3{\cdot}5}{1500 + 3500 \times (4{\cdot}2 \div 12)} = \frac{42{,}875{,}000}{1750} = 24{,}500 \text{ lbs.}$$

The range for security is given from $\frac{1}{10}$ to $\frac{1}{60}$. Assuming, then, the rule of Major Sanders as correct, the deduction from this rule would be $\frac{2}{11}$.

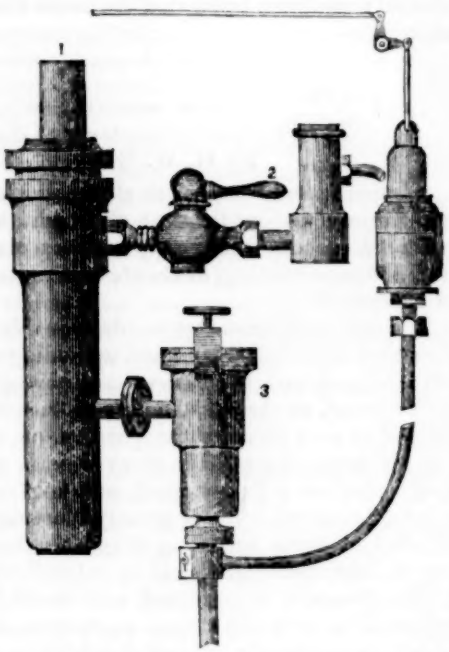
Potez, ainé, and Thibaut's Boiler Feed.

From the Practical Mechanics' Journal, May, 1866.

This apparatus is a combination of the two inventions, one called the stokers' aid, (*aide-chauffeur,*) and the other the self-acting clearing cock, (*purgeur automate.*) The former is the invention of M. Potez,

ainé, and the latter of M. Thibaut, of 34 Rue du Rendezvous, Paris. The contrivance is calculated to insure in the best manner a self-acting and regular supply of water to steam boilers, and, as a matter of consequence, will diminish the risk of explosion and the too frequent disastrous consequences.

The piece No. 2 on the illustration, the stokers' aid, is simply a tube placed laterally in communication with the tube No. 1 of the force-pump, above the clack-valve. The tube of the stokers' aid has its extremity raised to a vertical position, and is terminated by a brass mounting on which rests a sort of valve with an india rubber seat. When this valve is closed no effect is produced, and the pump works as usual; but when once the valve is, on the contrary, raised above the seat, the pump ceases to inject and draws nothing but air. To produce the alterations of closing and opening according to the required supply of water in the boiler, it is only necessary to connect by a vertical rod and a series of cranks and wires, or some like contrivance, the valve with a float in good order, so that every time that the water in the boiler will rise above the normal level the pump will cease to inject. If the pump could commence acting as soon as the water in the boiler had fallen below a certain level, the problem would be completely solved. This is managed by aid of the blow-off, (*purgeur*,) No. 3, consisting of a cock of small section, furnished by a spring-valve, which allows to escape at each stroke of the pump a portion of the air and water introduced through the clack-valve. Thus, an undue or accidental pressure is prevented from being exerted in the body of the pump after the shutting of the injection-valve. This condition being of the utmost importance, especially when the boiler is fed with water at high temperatures, this absence of pressure is all that is necessary to insure the self-action of the pump. In fact, the cock No. 3 allows the pump to act freely every time that, by the closing of the orifice of the stokers' aid or piece No. 2, the feed must again be renewed.



"We have submitted," adds M. Tresca in his report, "this double apparatus to very severe tests, since, after having assured ourselves that

it would work with cold water, we supplied the cistern of the pump with water from 98° to 100° centigrade, (boiling point,) without any irregularity happening in the feed. The working of the apparatus has been closely superintended for two months, and the accuracy with which it has constantly maintained the level of the water in the boiler to within 2 centimetres (four-fifths of an inch) of variation, enables us to give the best testimony as to its efficacy. Its employment is sure to be advantageous, at the same time diminishing the labor of the stoker. The only condition being that the boiler float be kept in proper working order."

For the Journal of the Franklin Institute.

The Practical Advantages of Superheating Steam.

By H. W. Bulkley, New York.

"Superheated" steam, or steam which has received an increase of temperature without increase of weight, by the direct application of heat, has enemies who stoutly maintain that no benefit can be derived from the superheating, as the steam has its maximum efficiency as soon as generated.

The fallacy of such statements are evident on reflection, and plainly show that those advancing and upholding them have neither practical acquaintance with the subject, nor have given it serious thought. It is clear that, as the greater part of the steam generated in boilers is obliged to pass through the water above it, on its way to the steam-pipe, it must unavoidably carry with it much water in the form of spray, *mechanically* combined, and held in suspension. When boilers "*foam*," this operation is greatly increased by unnatural causes, the delivery of spray becoming so great as to seriously inconvenience the engine, and endanger *its* safety, as well as that of the boiler. And in boilers properly constructed and carefully operated, which may be supposed to work dry steam, *much more* water than is generally conceived, is constantly carried over with the steam, and this defect cannot be *entirely* remedied, even by the most judicious arrangement of "dry-pipes," steam-drums, &c. What then becomes of this water mixed with the steam, and which has been heated at the expense of the fuel? It is evident that it is useless for *power*, and, as it has no latent heat, is very unavailable for heating or drying purposes. It cannot act otherwise than as a "clog," causing more friction in the steam by its presence, inconveniencing the operation of the engine, and tending to condense the steam with which it is associated. Now, by superheating this wet, saturated steam, it is converted into an elastic vapor by the complete and instantaneous vaporization of its surplus moisture, while its temperature is raised sufficient to preserve it from premature condensation in passing to the cylinder, or to the heating or drying coils.

The volume and elasticity of the steam is thus increased to a wonderful extent by a very moderate degree of superheating, and its subsequent operation in the cylinder is highly satisfactory.

But another advantage in the system should not be overlooked, and that is, the expansion of the steam *as a gas*, by the heat imparted to it *after* its surplus moisture has been evaporated. Although, as is evident, the *greatest* gain must ensue from the addition of the *first few* degrees (say 50) of heat, when the expansion of the steam from its previous saturated condition is very great, yet the highest authorities agree, that after it is thoroughly dried, the steam follows the laws of gases, and its volume may be doubled by the addition of 480 degrees of heat.

It is a fact proved by most accurate experiments, that the higher the degree of superheating, the greater is the economy, and if steam could be used at a temperature of 1000 degrees, its efficiency would be *very largely* increased.

Inasmuch as it is not practicable or convenient with engines, as at present constructed, to use steam at such extreme temperatures, we are unable to realize the greatest economy of superheating, but if ordinary steam of 50 lbs. pressure, at a temperature of 301 degrees, be superheated to 400, the addition of this 99 degrees of heat will augment its volume (or pressure) more than 20 per cent., and will not render it at all injurious to the lubrication or packing.

Where this superheating is effected by the waste products of combustion, the increase referred to is all clear gain, but when acquired, as is frequently done for convenience, at the expense of the fuel, a simple calculation (omitted here for want of space) shows that *even then* the economy from the expansion as a gas is from 10 to 15 per cent., *independent* from that realized in the vaporization of its surplus moisture, (as explained,) and which is as much more.

Saturated steam cannot part with any of its heat without becoming condensed, and this loss by premature condensation is often a very large per centage of the total amount of steam used. In every unit of the steam thus condensed there are lost 1000 units of heat, which have been supplied by the fuel, but have not been utilized. Superheated steam under the same circumstances might lose all of its surplus heat, but would still exist as steam.

In England, where the practical advantages of superheated steam are more thoroughly understood, and generally acknowledged, its employment is common, and is attended with most satisfactory and economical results. The steamers of the "Peninsular and Oriental Steam Navigation Company," have used superheated steam for many years, and its Directors certify that it has saved them many thousands of tons of coal.

In this country the steamers of the "Bay Line," running between Baltimore and Fortress Monroe, employed superheated steam, with an economy of 30 per cent. in their fuel. The steam, which was superheated by means of an arrangement of tubes in the uptake, was maintained at a temperature of 400 degrees in the cylinder, yet a subsequent inspection of its interior surface, after using this steam for several months, showed it to be as smooth and polished as a mirror.

The writer's experience in the practical application of superheated

steam with stationary boilers has shown that where the steam was superheated, *by the fuel*, about 100 degrees above the temperature due to its pressure, (giving a temperature of 400 degrees in the cylinder,) the saving in feed-water, or *steam*, was nearly *one-third*, and the economy *in fuel* was *one-quarter*, showing that from 5 to 8 per cent. of the fuel was required for superheating the steam generated by the remainder, thereby increasing its efficiency nearly one-third. With this temperature maintained in the cylinder, by a judicious arrangement of the superheating apparatus, the operation of the engine was highly satisfactory, no water being present to necessitate the opening of water-cocks, or bring undue strains upon the cylinder-heads or connexions. It is hardly necessary to add that no appreciable action could be observed upon the lubricants, packing, or working surfaces of the engine.

The *full* economy due to the use of steam expansively cannot be realized when it is employed in the saturated condition, owing to its partial condensation during expansion. As heat and power are correlative terms, steam cannot perform work without the elimination of a portion of its heat, besides that lost by radiation. This heat, corresponding to the work done, may be taken from superheated steam without destroying its efficiency; for it will still remain in the cylinder, pure and dry, to the end of the stroke. It can be confidently asserted that no *steam* engine is entitled to that name, if it employs a mixture of water and vapor, instead of the genuine article.

The objections sometimes advanced on the score of "want of durability" in superheating apparatuses, may be entirely removed by the exercise of a proper care in their construction and application, and by the allowance of a liberal amount of heating surface, so that it is not necessary to subject the superheaters to an undue degree of heat, which would naturally tend to their destruction. These particulars faithfully complied with, it will be found that no tangible objections can be opposed to the employment of moderately superheated steam, and when such economical results obtain from its use, it seems unaccountable that it is not more generally appreciated, and that the manufacturing public still adhere to the old saturated article, wasting by it both their time and money.

The practical advantages attending the use of superheated steam, either when used as *power*, or for *heating* and *drying* purposes, are immense, and it is to be hoped that, with the increased diffusion of knowledge, the old fogy prejudices against it may be removed, while its true merits are openly and universally acknowledged.

No. 57 Broadway, N. Y., August 29, 1866.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Anchor-ice. By JAMES B. FRANCIS, C. E.

Articles have appeared in the May and August numbers of this *Journal* relating to the obstruction of the strainer of the inlet-pipe

of the Detroit Water-works by ice in 25 feet depth of water. As suggested by Professor Henry, this is undoubtedly an example of *ground* or *anchor-ice*. Perhaps a brief account of some of the circumstances attending this curious phenomenon, in another place, may aid in elucidating the Detroit example.

The manufacturing establishments at Lowell are driven by water-power derived from a fall of about 34 feet at Pawtucket Falls in the Merrimack River. The dam at the head of the falls sets back the water about eighteen miles to the foot of the next fall above. Usually, before the middle of December, the entire reach of eighteen miles is frozen over. In ordinary stages of the river, nearly its whole flow is diverted into the canals by the dam, and is used by the manufacturing establishments. The current in most of these canals is too rapid to allow them to be frozen over. At times, the operation of the mills is seriously interrupted by anchor-ice, the formation of which is evidently connected with the open water, as at the mills which are supplied with water from the river through canals which are frozen over, there is no anchor-ice, while at others, supplied from the same source, through canals not frozen over, great trouble is experienced. In fact, it is uniformly observed that anchor-ice is found only at or below open water. The water is usually kept flowing through the canals during the night, when the mills are not in operation, passing over dams or weirs constructed for the purpose. During some part of most winter nights anchor-ice forms, and, in severe weather, men are employed through the night, in cutting it away from the tops of the dams, in order to prevent overflows.

Anchor-ice is an aggregation of small crystals or needles of ice, forming in the water a spongy mass, easily penetrated with any hard substance. It is frequently found adhering in large quantities to the bottom and sides of the water-courses, both open and covered. In clear weather, as the sun approaches the meridian, masses of anchor-ice often rise from the bottom of the open channels and float off, sometimes with earth and small stones adhering. It is produced in the greatest abundance in cold, clear, windy nights. It unquestionably originates at the surface of the water, the necessary conditions being, that the water should be at the freezing temperature, the air below that point and the surface of the water agitated, either by a current or by the wind. In its first stage, the ice is in small detached needles or crystals; if there is little or no current, this ice accumulates at the surface and finally consolidates into a sheet; if the current is too strong to permit this, portions of it accumulate in spongy masses, and float along at or below the surface, their specific gravity differing but little from that of the water. In a current of water there is a constant intermixture of the water at different depths, producing a uniform temperature at all depths, and tending to distribute uniformly foreign matters held in suspension. This takes place even in the most uniform and regular channels. Natural water-courses are almost always irregular in form; the more irregular the more rapid will be the intermixture.

The anchor-ice being formed in small crystals at the surface, by means of this intermixture, much of that which does not aggregate in masses, is carried down from the surface, and is distributed throughout the whole depth of the stream, much in the same manner as earthy matters are carried along in suspension by currents. These crystals have a strong tendency to adhere to each other or to any other solid bodies they may come in contact with. The adherence can only take place by freezing, that is, by a new formation of ice, and here lies the mystery of anchor-ice. How can water become ice without a loss of heat?

Anchor-ice is observed to adhere to surfaces of stone or wood, over which the water is running with considerable velocity, in some cases exceeding 20 feet per second, growing up under this rapid current at the rate of an inch or more per hour. It is clearly not dependent upon radiation in the manner Dr. Wells has shown dew to be formed, for we find the piers of bridges and the interior surfaces of subterranean water-courses, where there can be no loss of heat by terrestrial radiation, covered with anchor-ice.

Faraday has shown, (*Glaciers of the Alps*, by J. Tyndall, page 351,) "that when two pieces of ice, with moistened surfaces, were placed in contact, they became cemented together by the freezing of the film of water between them, while, when the ice was below 32° Fahr., and therefore dry, no effect of the kind could be produced. The freezing was also found to take place under water; and, indeed, it occurs even when the water in which the ice is plunged is as hot as the hand can bear." It has been suggested that the union in these experiments is accomplished by a process analogous to the welding of metals. It might account for the adherence of the crystals of anchor-ice to each other, but not to other substances.

The following explanation of the process has been suggested. The formation of ice is a kind of crystallization, requiring time for its development. Anchor-ice commences to form at the surface of water, agitated either by a current or by the wind. The water being at the temperature of 32° Fahr., and the air at a lower temperature, heat passes from the water to the air, equivalent to the formation of a certain amount of ice; the water being agitated and the ice in minute crystals, the latter become mixed with the water before all the ice due to the loss of heat is formed; and, although the crystals are removed from further loss of heat, they will continue to enlarge, until an equilibrium is attained. The amount of ice formed after the crystals leave the surface may be very small, but still be sufficient to cause them to adhere, when, by means of the current, they are brought in contact with each other, or with any other solid at the freezing temperature.

If this explanation is correct, the freezing process must continue for a considerable interval of time after the crystals leave the surface, as we have found, on drawing the water out of a subterranean water-course, the whole interior surface of the channel coated with anchor-ice, with great uniformity and symmetry, and several inches in thickness. This ice must have formed before it entered the subterranean channel and subsequently adhered.

Great inconvenience from anchor-ice is occasionally experienced at Lowell. It has been stated, that the dam there sets back the water about eighteen miles, forming a quiet reach of water usually frozen over early in the winter, which prevents the formation of anchor-ice on its surface. This ice is sometimes carried out, in the depth of winter, by a freshet. In December, 1863, this happened. On the 13th and 14th there were heavy rains, causing a rise in the river, which carried out the ice and discolored the water with earthy matter. In the night between the 15th and 16th, the wind was high from the north-west, anchor ice making freely with the thermometer at 30°. At 6 A.M., on the 16th, the wind was fresh and the thermometer at 26°, the anchor-ice forming very freely. The water-wheel for moving the sluice-gates of the Northern Canal could not be started, on account of anchor-ice having choked up the orifice through which the water is drawn. No anchor-ice is ever found at this wheel when the river is frozen over. The unusual amount of anchor-ice at this time, forming at such a high temperature, was attributed to the high wind and rapid current in the river, and the great extent of open water surface above the dams on which anchor-ice could form. Part of the anchor-ice thus formed passed into the canals, where it adhered to the sides of the water-courses and orifices, greatly obstructing the flow of the water. In such a case, the frozen surface of some of the canals is very little protection, as the anchor-ice made in the river becomes so thoroughly mixed with the water that it forms part of the stream at all depths, entering the canals with the water and flowing under the surface-ice. Strainers, used to prevent other substances than water from passing into orifices, are sometimes obstructed to such an extent that little or no water can pass through them.

The circumstances attending the formation of ice on the strainer of the Detroit Water-works do not appear to differ in any essential particular from that attending the formation of anchor-ice at Lowell. The depth of 25 feet, at which ice was formed at Detroit, is greater than it is found at Lowell, where none of the canals exceed 20 feet in depth, and are generally 10 feet or less. If, however, they were 25 feet deep, we should expect anchor-ice to gather at the bottom of them, pretty much as it does now, if the surface remained unfrozen.

Gun-cotton for Small Arms.

From the London Journal of the Society of Arts, July, 1866.

Gun-cotton, though largely used for blasting purposes in this country, has hitherto, in its employment as an explosive material in guns, not been so satisfactory as could be wished. Important progress has, however, been made in the practical application of gun-cotton since its study was resumed in this country about three years ago. Very large quantities of this material have been manufactured at the works of Messrs. Prentice, at Stowmarket, as well as at the Government Gunpowder Works, at Waltham Abbey. Its application to mining and

artillery purposes, and also to small arms, has been and still is the subject of systematic experiments conducted by the Government Committee on Gun-cotton. Its employment as a blasting agent is steadily increasing in several important mining districts in England, and a considerable, though not uniform, success has attended the employment of gun-cotton for sporting purposes.

In the early applications of this material, after Schönbein's discovery of it, great difficulty arose in its use, from the want of uniformity in its quality as well as from the absence of controlling power over its action as an explosive compound. It was found, as originally manufactured, that it was a very unstable compound, decomposing readily, and thus becoming liable to spontaneous ignition. Its true chemical composition was subsequently laid down by Hadow, and further investigations have confirmed his views; and we have been enabled, through the researches of General von Lenk, in Austria, and the valuable labors of Mr. Abel, in England, to get rid of many if not all the difficulties, and by an improved system of manufacture, carefully conducted, to produce an article which experience shows to be uniform in its character, and not liable to decomposition or spontaneous ignition. The most explosive gun-cotton is perfectly insoluble in mixtures of ether and alcohol, but by varying the proportions and strength of the acids employed for the conversion of the cotton, products of a less explosive character are obtained, which are more or less soluble in ether and alcohol, (forming the well known photographic vehicle, collodion.) It appears that the imperfections in the manufacture of gun-cotton arise from the introduction of foreign matters in the cotton, which can, however, be almost entirely got rid of, and, at all events, so small an amount is left as to produce no practical inconvenience. The rapidity of its combustion makes it valuable as an explosive agent for blasting, but this very property renders it in its pure form useless as a propelling agent for a projectile, where a regulated rate of combustion is required, generating an explosive force which gradually expels the bullet from the piece. The rapidity with which gun-cotton burns in the open air admits of ready and very considerable variation by applying the simple expedients of winding, twisting, or plaiting gun-cotton yarn of different sizes; but although a mass of gun-cotton may be made to burn in a comparatively gradual manner by being very tightly wound, a charge of the material in that form acts quite as destructively when in the bore of a gun as an equal charge consisting of the yarn wound, since the pressure of the gas established by the first ignition of the charge renders the close packing of the gun-cotton powerless to resist the instantaneous penetration of the flame between the separate layers of the material. This method of controlling, though asserted in the early days to be effectual, has turned out to be inefficient. Several methods, however, have been tried. The one adopted by Messrs. Prentice consists of forming cartridges of the gun-cotton diluted (so to speak) with cotton in its original form; and cartridges of this material have been constructed for sporting purposes, which give results that are stated to be very promising. Mr. Abel's

method consists in controlling the action of the gun-cotton by consolidating the material by pressure into compact homogeneous masses, and in confining the first ignition of such compressed gun-cotton in the bore of the gun to certain surfaces. Mr. Abel accomplishes this by reducing the gun-cotton fibre to a fine state of division or pulp, as in the process of paper-making, and converting this pulp into solid masses of any suitable form and density. This method of operating affords special faculties for combining both methods—dilution and compression—of reducing the explosive violence of the gun-cotton, and the results hitherto attained are very encouraging. A systematic course of experiments is now in progress, with the object of preparing the material for artillery purposes. A third method has been adopted by Mr. Dixon, who, instead of preparing his explosive material in the form of cotton, or cotton wool, and then dealing with the material by weaving, twisting, or plaiting, combined with some diluting agent, takes the woven material in the first instance and treats this with the combined acids of the proper strength, at the suitable temperature, subsequently washing the material in running water for a lengthened period, as in the most approved methods of making gun-cotton. Strips of this material, which the inventor terms gun-cloth, of suitable width and length, are then loosely rolled with thin tissue paper between the layers, thus accomplishing the dilution necessary for reducing the rapidity and violence of the explosion, and rendering the material suitable for the expulsion of the bullet. This roll is dropped loosely fitting into a cartridge, and is thus adapted for the rifle or for general sporting purposes. Mr. Dixon, it is stated, uses also a silica solution for further diluting the gun-cotton if required, and by varying the breadth and length of the tissue paper, he is enabled to modify the rate of explosion at different portions of the cartridge, adapting it in such a way as to render it most effective for the expulsion of the bullet. Some interesting experiments with these cartridges took place a few days since at Messrs. Bussey's factory in Holborn, with excellent results. Mr. Dixon states that, by using the gun-cloth, he attains a greater regularity and uniformity of manufacture; and by his method of rolling it, combined with the tissue paper, he obtains, by a simple, easy, and inexpensive process, a perfect means of regulating and adapting the discharge to the purpose for which it is required. As compared with gunpowder the gun-cloth cartridge for equal effect weighs one-third that of the powder. It may be dipped and thoroughly soaked in water, and after drying may be used immediately with unimpaired effect. This remark, of course, applies as well to other forms of gun-cotton. The experiment was tried at Messrs. Bussey's, and a cartridge having been soaked was dried and fired within three minutes.

Looking at the progress which has already been made in the manufacture and treatment of this material in the hands of Mr. Abel, aided by the elaborate series of experiments conducted and going on under his superintendence, as well as to the practical intelligence of Messrs. Prentice, and Mr. Dixon and others, there is no reason to doubt that

the application of gun-cotton with great advantage to some of the more important purposes for which gunpowder is used will, ere long, be fully established.

On the Combustion of Gas for Economic Purposes. By Dr. LETHEBY.

From the London Chemical News, No. 342.

(Continued from page 212.)

And now I am anxious to draw your attention to the effect of rarefying the atmosphere, for it has been noticed that the intensity of a flame is much less at high altitudes than at low. This was particularly observed by Dr. Frankland and Professor Tyndall in the autumn of 1859, when they were making experiments on the combustion of candles at the top of Mont Blanc. They noticed that although the candles burnt at the same rate as they did in the valley of Chamounix, yet the flames were blue, and large and feeble. Dr. Frankland was so much struck with the phenomenon that he afterwards made it the subject of careful investigation. He found, indeed, that a gas-flame, like that of a candle, gave less and less light with the rarefaction of the air in which it was burning; and its results show that the loss of light is about 5·1 per cent, for every inch of diminished mercurial pressure, up to a rarefaction of 14 inches. If, for example, the light of a flame be equal to 100 at 30 inches of the barometer, it is but 94·9 at 29 inches, and 89·8 at 28 inches; and so on up to 14 inches, when it is only 18·4 per cent. of the original light. Fortunately in our photometrical inquiries the loss of light is equally great with the gas and the standard, or the variations of atmospheric pressure from day to day, or even from hour to hour, would show a marked difference in the value of light. As it is, a variation of 3 inches of the barometer must cause a difference of more than 15 per cent.; and it is not improbable that this may have something to do with visible variations in the light of the public lamps. Certain it is that the same gas in places at different altitudes will have very different values. The gas, for example, which in London has the value of 100, would be but 91 at Munich, and only 61·5 in Mexico. Indeed, the difference would be greater than this, for not only is the light actually less for equal consumptions, but as the volume of the gas expands with the rarefaction and temperature, the real value of the same quantity of gas, as measured by the meter in Mexico, would be only 46·2. Even in London the difference in the value of the light, when the barometer is 31 as compared with what it is at 28, is fully 25 per cent.; and it may well be that this difference is noticeable.

If the rarefaction of the gas and air are carried to a very great extent they cease to burn. The flame of coal gas, as well as that of a candle and of spirit of wine and ether, is extinguished at a rarefaction of about $\frac{1}{3}$th of the atmosphere, hydrogen at $\frac{1}{4}$th, sulphur at $\frac{1}{15}$th, and phosphorus at $\frac{1}{80}$. On the contrary, if the atmospheric pressure is increased, the luminosity of a flame is also increased, and it would seem that up to considerable pressures the rate of increase is in the observed proportion of 5·1 per cent. for every inch of mercurial pres-

sure; and by doubling the atmospheric pressure the light of a gas-flame rises from 100 to 252. So marked is this on the luminosity of flame, that it is not difficult to make a spirit-lamp glow like a candle, or even to make it smoke.

And then there is another circumstance which influences the light of a flame, namely, the temperature at which the combustion is going on. If the temperature is lowered, the light is also proportionally diminished. This is noticed in the flame of a candle which requires snuffing, when the charred wick and the head of sooty carbon radiates the heat and lowers the temperature of the flame. But if by any means the temperature is increased, an opposite effect is produced. I have here a contrivance which was originally designed by Mr. Bowditch, and which has been somewhat modified by Dr. Frankland. It is a common Argand burner and glass, with another glass around it, and it is so arranged that all the air which supplies the burner must pass down between the glasses and be heated before it reaches the flame. The temperature which it thus acquires is from 500° to 600° Fahrenheit, and it passes to the flame as a sort of hot blast. The result of it is that the light for the same volume of gas is increased about 67 per cent., and for equal lights it is found that there is a saving of 46 per cent. of gas.

Illuminating Power with and without the external Glass in Sperm Candles of 120.

Consumption per hour. Cubic feet.	Illuminating power without glass.	Illuminating power with glass.
2·2	.....	13·0
2·6	.....	15·5
3·3	13·0	21·7
3·7	15·5	.....

These are the results with cannel gas, but I do not find there is a like increase of power with common gas.

Lastly, there are cases where the amount of carbon in the vaporous matter is so abundant that contrivances are needed for its oxidation. All these contrivances are plans for diminishing the supply of the combustible and increasing the flow of air. In the paraffin candle the wick is adapted for a small supply of the material; and in the benzole and paraffin lamps there are caps or deflectors, with slits for blowing the air upon the sides of the flame. In the camphine lamp there are additional deflectors in the form of a central button, and a throttled chimney for directing the air upon the inside and outside of the flame; and in the Carcel lamp the oxidation is increased by the length of the chimney. In all cases, however, the points for consideration are—the best means for effecting perfect and prolonged combustion; and, having attained this, we have to take care that the light is not destroyed by the medium of transmission. Glass is very transparent, but yet it destroys a notable proportion of light, and when the surface is ground the loss of light is often considerable:

Loss of Light by Glass Globes.

Clear glass destroys	12 per cent.
Slightly ground in pattern	24 "
Half ground	35 "
All ground	40 "
Opal glass	60 "

And, lastly, I have to refer to the methods which are adopted for estimating the value of the light of gas. These are as follows:

1. By observing the durability of a jet of gas of a given height from an aperture of a given size.

2. By ascertaining the pressure necessary to obtain a flame of a given height from the same jet.

3. By noting the height of the jet when the gas is burning from an aperture of a given size and at a uniform pressure.

4. By ascertaining the quantity of air which is required to destroy the light of a flame burning at a given rate.

5. By comparing the light with a standard flame.

The first method of testing the illuminating power of gas was often used by the late Dr. Fyfe, of Glascow, and when it was conjoined with another test, namely, the amount of condensation by chlorine, it was much relied on. The jet which he used had a diameter of the $\frac{1}{33}$d of an inch, and the flame was kept at a uniform height of 4 inches. In this way he found that a given volume of gas of different qualities burnt out in different times, thus:

Durability of a Cubic Foot.

Common Newcastle coal gas	50·5 minutes.
Wigan cannel	57·0 "
Lesmahago	65·0 "
Wemyss	75·0 "
Boghead	81·0 "

Secondly, he further ascertained that the pressure necessary to make a gas burn from an aperture of a given size, and with a flame of a given height, was also the exponent of the quality of the gas; for the better the gas the less the pressure at which it burns, and the less also is the consumption to produce a flame of a given height. For example, with a jet $\frac{1}{40}$th of an inch diameter, and a flame 5 inches high, the following were the rates and pressures of different gases:

Pressure. Inch.	Consumption per hour. Cubic foot.	Specific gravity of gas.
0·6	0·67	0·841
0·8	0·77	0·720
1·0	0·86	0·552
1·2	0·94	0·595
1·4	1·02	0·551
1·6	1·09	0·515
1·8	1·15	0·486
2·0	1·21	0·461

His deductions from these results were, that the specific gravity of the gas—or, in other words, its quality—was inversely as the square

roots of the pressures, and that the volume consumed in a given time was as the square roots of the pressures. He relied so much on this test, that he thought it capable of taking the place of both the meter and photometer.

The third method of ascertaining the value of gas is by observing the height of a flame at a given pressure from a jet with an aperture of a given size. This method has been adopted by Mr. Lowe, and it goes by the name of Lowe's jet. It is, as you perceive, a modification of the preceding, for a poor gas will burn with a shorter flame than a rich gas; and, by using a jet with an aperture of 0·04 of an inch in diameter, and a pressure of 0·5, the flame of 14-candle gas will be just 6 inches in height.

The fourth method for determining the quality of gas is by ascertaining the quantity of air necessary to destroy its light. The best instrument for determining it is the apparatus designed by M. Erdmann, and which is called a gas-prover. It is a sort of Bunsen burner, with a contrivance for graduating the supply of air. Erdmann recommends the gas to be turned on until there is a flame of a given height, and then the supply of air is admitted until the light is destroyed. This, however, is not the proper way to use the instrument. The gas should first be turned on at a given rate, viz: at the rate of 0·84 of a cubic foot per hour, and then the quantity of air necessary to destroy the light should be read off. In this way reliable results may be obtained, for the richer the gas the more air is required.

I referred in my last lecture to this diagram, which has been prepared from the experiments of Mr. King, of Liverpool.

Illuminating Power of Gas, as estimated by Erdmann's Gas-prover, the gas burning at the rate of 0·84 *cubic feet per hour.*

	DESCRIPTION OF GAS.			
	Newcastle coal.	Equal parts Newcastle and Wigan.	Wigan coal.	Boghead coal.
Height of flame, (inches)	1·87	2·00	2·75	5·50
Number of index prover	14·72	23·39	32·78	61·84
Relative value of do....	1·00	1·59	2·22	4·15
Co-efficient of power.....	0·70	0·70	0·72	0·70
Illuminating power (co-efficient = 0·7).	10·30	16·37	22·95	42·80
Do. do. by Photometer	10·30	16·35	23·58	42·96
Relative values.....	1·00	1·58	2·29	4·17

Lastly, the common method for ascertaining the illuminating power of gas is by comparing it with a standard flame.

In this country the standard was formerly a wax candle burning at the rate of 120 grains per hour, but the variations in the value of the light were so great that it was abandoned; for, as a wax candle requires snuffing, it was difficult to decide when it was burning in a

proper manner. After numerous experiments extending over a year, I ascertained that, for equal consumption, the light of wax and sperm was as 14 to 16; in other words, the power of sperm was just one-seventh greater than that of wax.

At present, the standard flame in this country is a sperm of six to the pound, burning at the rate of 120 grains per hour. But for some time past this standard has also become uncertain—first, because there has been great irregularity in the construction of the wicks; and, secondly, because the sperm is being adulterated with wax and paraffin, or both. The irregularity of the wick causes a variation in the rate of burning from 116 grains per hour to 140; and the real value of the light in the two cases, when reduced to the standard consumption of 120 grains per hour, is as 96 is to 116. The adulteration of the sperm with wax and paraffin also affects the value of the light, for the former gives 13 per cent. less light than sperm, and the latter gives 23 per cent. more light. These irregularities are becoming so serious that we must ere long change the standard.

In France the standard is a Carcel lamp of specified dimensions in every particular, burning refined colza oil at the rate of 648 grains per hour. With proper precautions this standard appears to be very uniform, care being taken that the consumption of the oil is never less than 617 grains per hour, or more than 679.

And now, in concluding this part of the subject, I will direct your attention to the comparative power and value of the most important illuminating agents.

Relative Value of different Illuminating Agents.

Name.	Rate of consumption per hour.	Illuminating power (Sperm 120.)	Quantity = 14 candles.
Cannel gas.....	4 feet	18·67	3 feet.
Coal gas.....	5 "	14·00	5 "
Benzole.....	301 grs.	4·91	857 grs.
Paraffin oil.....	265 "	7·11	522 "
Sperm oil.....	686 "	10·00	960 "
Colza oil.....	648 "	9·01	1008 "
Paraffin candles....	122 "	1·46	1171 "
Sperm "	132 "	1·35	1440 "
Wax "	168 "	1·43	1652 "
Stearic "	140 "	1·13	1732 "
Composite "	144 "	1·08	1858 "
Tallow "	145 "	0·83	2542 "

With regard to the value of other illuminating agents, as the magnesium light, the oxyhydrogen, or Drummond light, and the electric light, little can be said, as they vary so much with the consumption of the material.

In the case of the magnesium light, I find that when a wire the 100th of an inch in diameter is doubled and twisted, it burns at the rate of 2·4 grains per minute, and gives the light of about 69 standard sperm candles. An ounce of the wire, therefore, is equal in light-giving power

to rather more than 3½ lbs. of sperm candles. The power of the Drummond or oxyhydrogen light varies with the combustible used. With

Coal gas	and	air	it is equal to	19	candles.
"	"	oxygen	"	29	"
Alcohol	"	"	"	68	"
Ether	"	"	"	76	"
Hydrogen	"	"	"	153	"

And the power of the electric light varies from 650 candles to 1444, the average being about 1000.

All these agents are expensive, and they give a light which is characterized by intensity rather than by quantity; but as the light is pure as well as powerful, it is frequently used for signals and for photographic purposes, and also for theatrical illustrations.

I now pass to a very interesting part of our subject, namely, the cause of the marked differences in the color of the flames of different substances; and in order that you may perceive the reason of this, let me remind you that a pure white light, with all the colors of the spectrum, is never obtained but by the intense ignition of solid or molten matter. This is so with the phosphorus flame, and with the magnesium, the oxyhydrogen, and the electric light. In all these cases there are particles of concrete solid matter in a state of intense ignition, but in the case of coal gas, and in that of burning hydrocarbons, the light is never pure unless it is intensified by very energetic combustion. The reason of this is that the particles are only heated to the point of yellow whiteness; for Dr. Draper has shown that, according to the temperature, an ignited solid (as a spiral of platinum heated by the galvanic current) passes through all the tints of the spectrum from red to white, according to the intensity of the heat, and these tints and temperatures are somewhat as follows:

Very dull red	about	970°	Fahrenheit.
Cherry-red	"	1500	"
Full red	"	2000	"
Dull red, white, or orange	"	3000	"
Yellow white	"	4000	"
Greenish white	"	5000	"
Bluish white	"	6000	"
Perfect white	"	7000	"

If, therefore, the temperature of combustion is not sufficiently high, the light is never pure. This is especially so with the creamy lagging flame of underburnt gas, and with the smokey flame of hydrocarbons rich in carbon, as benzole, turpentine, and paraffin; but if the combustion of these flames is intensified by a proper supply of air, the temperature of the ignited carbon is increased, and the light becomes purer and purer, so that when it is thrown upon colored objects it displays the tints in a more or less perfect manner. Such a flame, when examined with a prism, gives a spectrum like that of solar light with all the tints of the rainbow. This is the speciality of pure light from an ignited solid. If, however, the vaporous matter does not contain solid particles in a free or concrete form, the ignition of it produces only certain tints of the spectrum, and hence its variable colors. Examined,

therefore, with a prism, we see only those bands of color which are characteristic of the flame.

I will show you this by moistening little balls of coke with the chlorides of the following metals, and then introducing them into the colorless flame of a Bunsen burner, or, better still, into that of Griffin's blast jet; and you note how different are the tints, and how they fail to illuminate certain colors of these dyed ribbons.

Chloride of sodium	gives a rich yellow flame.
Chloride of copper	" a deep blue-green flame.
Chloride of strontium	" a rich scarlet flame.
Chloride of barium	" a pale pea-green flame.
Chloride of lithium	" a bright crimson flame.
And a salt of thallium	" a beautiful grass-green flame.

The chlorides are used because they are the most volatile, and they exist in the flame in a vaporous condition. These tints are so characteristic of the several metals, that they afford the most delicate means of discovering their presence; but the great fact which modern investigations have brought out is the circumstance that the spectrum of these flames consists of certain well-defined and constantly placed bands of color. This diagram will show you the spectra of the metals which I have been using; and so true and constant are the positions and tints of these bands, and so delicate are the manifestations of them, that they become the means of discovering the merest traces of the several metals. But I must not pursue this further, except by showing you the differences in the tints of this spectrum and ribbons when examined with the pure white light of burning magnesium.

And now I will briefly describe the contrivances which are used for increasing, or rather, I should say, for fully developing, the temperature of burning gas. I have shown you that the light of a flame depends on the presence of ignited carbon; if, therefore, by any contrivance, we can at once burn this carbon, and not permit it to stand, as it were, idle, in an ignited condition, the temperature must be considerably increased. This is the principle concerned in all the contrivances for developing the heat of gas.

One of the simplest means of accomplishing this is to mix a sufficient quantity of air with the gas before it reaches the place of combustion; and this is easily done by putting a cap of wire gauze upon the chimney of an Argand burner, and setting fire to the gas above it. The effect of this arrangement is that as the gas passes from the burner to the top of the chimney, it draws in a quantity of atmospheric air, which freely mixes with it and burns the solid particles. The same is the case with the burner of Bunsen, which I have already described; and you will note how strongly it ignites this platinum crucible. The same arrangement is adopted by Mr. Griffin in his reverberatory furnace, which is a Bunsen's burner enclosed in a clay chamber. I have here another contrivance of the same nature called an *atmopyre*, which is used by Professor Hofmann in his furnace for effecting organic analysis. It is a hollow cylinder of baked pipe-clay pierced with a large number of small holes. When it is placed on a small fishtail

burner, the gas, in issuing from the holes, draws in a sufficient quantity of atmospheric air to make it burn at all the apertures with a clear blue light; and thus the temperature is so much increased that the entire body of the numerous cylinders composing the furnace becomes almost white hot.

But we shall find that a still higher temperature is obtained by blowing air into a large volume of flame. This is the plan adopted by Mr. Herapath in this blow-pipe jet. Observe how intensely it ignites a mass of platinum wire; and by putting together a number of these jets, as Mr. Griffin has done, in this arrangement, which he calls a blast-furnace, you will perceive what a high temperature is obtained; and by surrounding the blast with a case of baked clay, so that the heat may be concentrated, the temperature is sufficiently high to melt all the common metals. As much as a quarter of a hundred weight of cast iron can be melted at a time in one of these furnaces, and 3 or 4 lbs. of cast iron or copper can be thus melted in fifteen minutes. Even the very refractory metals, as nickel and cobalt, can be thus fused.

And if, instead of atmospheric air, a jet of oxygen is used, as I will now show you, the temperature is still higher. This is the principle of Deville's furnace, which is a jet of oxygen blowing into a large flame of coal gas, and directed down upon the refractory substance, the whole apparatus being enclosed in a chamber of non-conductors. With this furnace large masses of platinum are easily melted, the platinum being placed upon a hollow bed of lime. I have seen a mass of platinum, weighing about 350 lbs., which had been melted in this manner, and I was informed by Messrs. Johnson and Matthey, the platinum assayers of Hatton Garden, that the mass required six hours for its fusion. During that time about 360 cubic feet of coal gas and the like quantity of oxygen were used. In fact, Deville found in his experiments at the *Ecole Normale*, that it required a little more than a cubic foot of gas and a cubic foot of oxygen to melt a pound of platinum. The temperature of the flame must be enormous; calculated from the thermotic powers of gas with air and oxygen, it may be said that it is equal to about 5228° of Fahr. when air is used, and 14,320° Fahr. with oxygen.

(To be continued.)

For the Journal of the Franklin Institute.

The Working Processes for the Reduction of the Gray Copper (Tetrahedrite) Ores at Stefanshütte, in the Comitat (County) of Zips, in Hungary. By J. L. KLEINSCHMIDT.

(Concluded from page 172.)

Amalgamation or Extraction.—The extraction is in operation since six years at the Stefanshütte, and was started by the director of the melting works, Mr. I. Ferientschick. It is mostly used to obtain the copper from the abzugsspeiss, (see below.) Although the experiments which were made there to extract the silver from the black copper and the speiss gave a good result, the amalgamation is yet in use, partly because the amalgamation is now in successful operation, partly

because there was no pecuniary advantage visible by changing the amalgamation into extraction. In examining both methods more exactly, there is no great difference between them. In both, the chloride of silver formed is dissolved in a solution of common salt, which will be evident, by remembering that there is salt lye taken to the quick-brei, (quickmud,) and that the lye is strengthened yet by common salt. If not all the chloride of silver should have gone into solution, this will be the case in course of time, as the silver is precipitated by the copper. In the one as in the other method, the silver is precipitated by copper. In the amalgamation this silver is taken up by the quicksilver, while by extraction the most of it can be obtained pure. In the amalgamation at the Stefanshütte the copper remains in the solution, and is precipitated from it by lime, and then comes to the melting. By the extraction process the resulting copper is more pure, but the copper could be precipitated too, from the quicklye, in a metallic state, if it was not more convenient, on account of the small quantity of it, to precipitate it by lime, and to melt this precipitate together with the residues, (rückstände.) The main disadvantage of the amalgamation, therefore, is in the use of the quicksilver and the loss thereby. Since the part of the quicksilver in the amalgamation was better known by the extraction, the loss of it is only small. Most of the losses by amalgamation are occasioned from dispersed (zerschlagenem) amalgam, which dispersion flouring, again, takes place easier when the quicksilver is affected, as when this is not the case. That the dispersion of the amalgam is the main cause of the losses of silver, even by the American amalgamation, I discovered during my stay in the mines of Anqanqueo, in Mexico, in the years 1850–51. At the hacienda of St. Gabriel I found a great many tailing muds, (schlämmen,) which were deposited in the pools through which the powders took their way after the washing of the quick heaps, (montones.) These contained in 100 lbs. 1 to 3 ounces of silver. By cautious washing and addition of quicklime, I obtained a great quantity of amalgam from them. The main advantage of the amalgamation is, that the silver is sooner gained, and the production of a marketable silver can take place easier without residues than by the extraction, where it is not possible to get from a certain quantity of black copper, &c., all silver in a pure state, because a part remains always with the copper. At the Stefanshütte, therefore, such copper was amalgamated to get the silver at once from it.

In respect to the health of the workmen, those employed in the quickroom (quicksaal) were not affected from any peculiar sickness, although their white coats were colored quite green. The workmen at the roasting for amalgamation were affected with vomiting as long as they were not accustomed to the work. Those employed at the roasting for quicksilver were affected partly with nervous trembling, (hüttenkatze,) which is ascribed in common only to the lead, but particularly by running of the spittle and loss of teeth.

Speissverlechung.—Melting of the Speiss Residues with Pyrites.—The object of this operation is the production of a marketable crude antimony metal, and the extraction of the copper contained in the

residues of the amalgamation. The latter is done by transferring the copper into matte.

The roasted residues from the speiss amalgamation, which are free from silver, are melted with 85 to 95 per cent. of pyrites from Schmöllnitz, (kiese,) 12 to 18 per cent. of quartzy ores, and 120 to 130 per-cent. of rostslag. Lately, by this process, a great many of the matte obtained by the melting of the residues from extraction were worked up. A last mixture, July, 1863, consisted of—wet remains (18 per cent. water) 100, roasted matte 48, quartzy ores 28, limestone 8, copper slag 36, pyrites of Schmöllnitz 60. The mattes mentioned were roasted by 8 fires, and contained 5 to 6 per cent. of copper. Herefrom resulted matte with 14 to 16 per cent. of copper, and a speiss, (crude antimony metal,) very white, and almost free from iron.

The composition of the crude metallic antimony from this melting were, on different days,—

1.	
Cu	5·73
Co and Ni	1·50
S	2·00
Sb	90·77
	100·00

2.	
Cu	7·3
Fe	1·1
S	2·3
Co and Ni	1·5
Sb	87·8
	100·0

3.	
Fe	trace.
Cu	11·0
Co	...
Ni	1·0
Sb	86·0
S	2·0
	100·0

4.	
Fe	2·0
Cu	10·5
S	2·5
Co and Ni (in about equal quantities)	1·5
Sb	83 5
	100·0

5.	
Cu	13·50
Ni	1·20
Sb	83·30
Fe	trace.
S	2·00
Co	...
	100·00

6.	
Cu	9·0
Fe	1·6
S	2·4
Co and Ni	1·5
Sb	85·3
	100·0

1 and 2 from different days, large crystals; 3, 4, 5, and 6 are from the same regulus.

3, large crystal above.
4, " " below.
5, small crystallized, from the side in the midst.
6, " " " " above.

The crude antimony metal produced by this process is salable, and there is a great demand for it. Its composition shows what it can be used for. It is bought by the manufacturers of regulus antimonii in upper Hungary, who purify it still further. It has already been mentioned that cobalt and nickel are concentrated in the speiss. On account of the great amount of iron in the crude speiss, and the small quantity of the former metals in it, it was not possible for me to determinate them quantitatively.

Crude antimony metal, (Rohantimon,) produced 1862; *analysis by the wet way. White with reflecting surfaces.*

Sb	85·00
Cu	10·00
S	2·00
Co and Ni	1·50
	98·00

Method of Analysis.—The metal was reduced to fine powder, dissolved in fuming nitric acid, the diluted solution, after settling, filtered, and the copper precipitated by hydrosulphuric acid. The residue on the filter was quite white. It was dried, ignited, weighed and calculated as SbO_4. It was melted before the blow-pipe with cyanide of potassium and carbonate of soda, but no other metal was found in it. The hydrosulphuric acid precipitate was dissolved in nitric acid, and then the copper by caustic potash. The filtered fluid from the hydrosulphuric acid precipitate, after driving out the hydrosulphuric acid by boiling, oxidation by chlorate of potash, and filtration was precipitated by soda lye, filtered, ignited, and weighed, and then determinated as $(Co\ Ni)_4\ As$, by Plattner's method. In this case the metallic globule contained no iron. This method I found more convenient and exact than the reduction of the oxides by hydrogen, although, in this case, the oxides were not separated, as this was the case by the speiss produced from the residue of the extraction, (see below.)

Arsenic.—The ores, as well as the pyrites, (kiese,) contain arsenic, which should be concentrated in the speiss; therefore I directed my attention to it. The most simple method is to melt the speiss with cyanide of potassium in the inner blow-pipe flame. In this manner I could detect arsenic in the most samples of sulphuret of antimony from Rosenau, and the mines in the vicinity, notorious for its purity; but this was never the case with the refined speiss, (crude antimony metal;) therefore in an especial trial I concentrated the nitric acid solution, filtered off from the antimonic acid by addition of sulphuric acid, until all the nitric acid was driven out. The salts were dissolved in water, boiled with sulphurous acid, to reduce the arsenic acid, the copper precipitated by hydrosulphuric acid, filtered immediately, and treated further by hydrosulphuric acid. The small precipitate thus produced was mixed with cyanide of potassium and carbonate of soda, and melted in a sealed glass pipe. Neither by this method nor by smelting before the blow-pipe, arsenic could be detected in it. Therefore the arsenic is completely volatilized by melting in the high furnace.

In managing the melting process, I had to try almost daily the crude antimony metal produced, and as it was necessary to know the results immediately, I searched for a method to do it sooner than in the ordinary way. I found this before the blow-pipe, and succeeded to determinate the constituent parts, with an accuracy more than sufficient, in time of $1\frac{1}{2}$ to 2 hours. It is the following:

From the regulus to be tried 100 to 150 milligrammes are weighed. When in pieces it is used in that state; when in powder it has to be melted with some cyanide of potassium and borax, in a cylinder of

soda paper before the blow-pipe, or in a crucible, (tute;) in the latter case by addition of some black flux. The resulting metallic globule is very cautiously melted in a small pit of the blow-pipe charcoal in the inner flame, as long as iron is absorbed by the slag. While this is the case no antimony is volatilized. The moment antimonial smoke is seen, the blowing is interrupted, and the globule covered with the cold blow-pipe hammer or anvil. The globule is separated from the charcoal, boiled with diluted hydrochloric acid and weighed. If the sample consists of one lump, the iron can be determinated by titration. For technical use the accuracy is sufficient, if the difference is considered as matte, and 26 per cent. of sulphur calculated in it. But as the crude regulus, free of iron, contains 2 per cent. of sulphur, this quantity must be calculated anyhow. Some practice having been gained in this manipulation, the resulting globule differ not a half milligramme. Now the blowing, by addition of some borax, is continued. The borax pearls show no more trace of an iron reaction, a great deal of antimonial smoke emanates, and the globule burns by itself. The smoking ceases after some time, a new piece of borax-glass is taken, and the resulting beads gathered, which show cobalt and then nickel reaction. By comparing them with beads of a certain amount of cobalt and nickel, it is possible to estimate both metals very near. By some practice a copper globule can be obtained at last, free of nickel and antimony, which has lost very little copper. This is hammered on an anvil, whereby it must not get any edge cracks, and weighed. The difference without cobalt and nickel, and 2 per cent of sulphur, gives the antimony.

The above analyses, 1 to 6, have been made by this method. They show that in one and the same regulus (könig,) the constituent parts are not uniform, but that they are differently arranged in the crystals. The surfaces of the great crystals are blue-white, reflecting, and somewhat rough. The crude antimony metal is the more blue, when containing more copper, and the more gray, when iron is prevalent. The small crystals seem to be formed by rapid cooling, and therefore mainly on the margin, the large ones in the middle. The workmen recognise at once its quality from the smoke which emanates after the matte has been taken off. The stronger it smokes the more antimony it contains. The mattes obtained by this process contain 14 to 16 per cent. of copper. They are partly roasted with 5 or 6 fires, and are melted with the black copper residues from the amalgamation. According to the method before the blow-pipe, mentioned above, it was thought possible to work up the speiss in the spleiss furnace, by volatilizing the antimony, after the speiss residues are melted down in a high furnace. But the experiments were soon discontinued; first, because the process was too expensive, as the copper had to be subjected to a very long and intense heat, to drive away the antimony, but more yet because a copper resulted which could not be used for any practical purpose.

When these mattes are worked by themselves, by roasting them according to the method of the Phönixhütte, with 8 to 9 fires, and then melting to black copper, the latter has the following composition:

Speiss Rückstand Verlechungs Schwarz-kupfer. (Black Copper from the Residues of Amalgamated Speiss by Melting them into Matte, from the Matte of 1864.)

Cu	72·64
Sb	23·09
S	0·99
Co	0·10
Ni	0·10
Fe	3·08
	100·00

Method of Analysis.—1 gramme was dissolved in aqua regia, the acid evaporated until only a small quantity of chlorhydric acid was present, dissolved in water and tartaric acid, the filtered solution precipitated by chloride of barium, (S in subst. 2 mgr.,) copper and antimony precipitated by hydrosulphuric acid, the copper in this determinated by titration, the filtered liquid boiled with sulphuric acid, and chlorate of potash, and ferric oxide, oxide of cobalt, and nickel, after the separation of the sulphate of baryta precipitated by soda lye. After weighing, (47 mgr.,) the precipitate was melted with arsenic, &c., and cobalt and nickel separated before the blow-pipe, (Co and Ni)$_4$ As = 3 mgr., ferric oxide from second trial precipitated by ammonia, (44 mgr.,) antimony by loss. The black copper has a "speissy" appearance, color light-gray, here and there changing in brass-yellow. The analysis shows that these black coppers contain more cobalt and nickel than the black copper produced from the residues of the argentiferous black copper, and the copper produced from them is inferior to the copper from argentiferous black copper, (rückstands kupfer.) The only way to improve the quality of these coppers would be to roast the matte only so far that by their melting, a small quantity of black copper (speiss) is produced, and to work up the latter with the speiss from the refining slags, (abzugsspeise,) which, it is intended, will hereafter be done.

Refining Slags, (Spleissabzüge.)—The refining slags contain 20 to 25 per cent. of antimony; therefore they must be worked up by themselves. It is not possible to melt them by an addition of basic slag and lime in a shaft furnace, and to refine the resulting copper in the spleiss furnace; thereby an inferior copper is obtained, and the refining in the spleiss furnace takes too long time and costs too much fuel. The method in practice now is to melt the refining slags with pyrites, (kiesen.) For this purpose they are melted with 70 to 80 per cent. of pyrites from Schmöllnitz, 10 to 15 per cent. of quartzy ores, and 90 per cent. of slags from the melting for argentiferous black copper, in a shaft furnace, and copper matte containing 36 to 38 per cent. of copper, and speiss is the result. The composition of the latter is—

Abzugsspeise. XI. Abs. (1st party to extraction.)

Co	0·74
Ni	1·15
Cu	37·50
Fe (Ag trace only below the muffel,)	11·69
S	3·19
Sb (from the loss)	45·73
	100·00

Method of Analysis as above.—The composition of the speiss shows why by the simple melting of the abzüge (refining slags) no good copper can be produced. The cobalt and nickel, in combination with the antimony, render the copper brittle and not manageable under the hammer. To make a good copper from the refining slags it is best to carry them into the speiss, that is, to combine them with the antimony, whilst most of the copper combines with a part of the sulphur of the pyrites (kies) forming matte.

The copper mattes obtained hereby contain 36 to 38 per cent. of copper, and are roasted either with four fires, and then added to the residues of the amalgamation of the black coppers, as stated above, or roasted with 8 or 9 fires and melted to black copper, and the latter refined by itself. The copper obtained in the latter manner is of inferior quality to that from the residues of the black copper amalgamation, but it contains only such minute quantities of nickel that the latter could not be determinated.

Abzugs Schwarz-kupfer. (*Black Copper from the Refining Slags from the Mattes, March*, 1864.)

Cu	84·52
S	1·06
Fe	1·58
Co	0·18
Ni	0·27
Sb	11·30
	98·91

Hammergaares Abzugs-kupfer. (*Toughened and Refined Copper from the preceding Black Copper, March*, 1863.)

Cu	98·33 by loss.
Sb	1·67
Ni	trace.
	100·00

The black copper has a dented, hackly fracture; color gray, in a great many places copper-colored. It can be stamped, but only to small pieces, not to a fine powder, because it gets flattened. From the composition of the black copper it is visible that it contains more cobalt and nickel yet than the black copper of the speiss residues of the amalgamation from the mattes, (speise-rückstands-verlechungs-kupfer,) which is in accordance to the cobalt and nickel in the speiss from the refining slags (abzugsspeise), because while the crude speiss contains so small quantities of cobalt and nickel that they could not be determined. These metals amounted in the speiss from the refining slags to 0·74 per cent. of cobalt, and 1·15 per cent. of nickel.

Black Copper.—Method of Analysis.—It was dissolved in pure nitric acid; the residue, after weighing, melted with cyanide of potassium, &c., whereby no other metals were found; the solution precipitated by hydrosulphuric acid, and in the precipitate the copper determinated by titration; cobalt and nickel were precipitated together with the ferric oxide by soda lye, weighed, arsenicated, and cobalt and nickel determinated and separated before the blow-pipe.

Toughened Copper.—It was dissolved in fuming nitric acid, and treated as the preceding. The antimony globule before the blowpipe gave a small nickel reaction. The solution was precipitated by

hydrosulphuric acid, the precipitate filtered, and to the filtered liquid, smelling after hydrosulphuric acid, soda lye added in excess, whereby it became quite black. It was put away until the precipitate was settled, and the liquid above it was clear. The precipitate was filtered, roasted, to drive away the sulphur, and melted with arsenic and cyanide of potassium; whereby such a small nickel globule was obtained that it could not be weighed. By using the same method in the analysis of the copper from the ordinary black copper residues, the liquid turned black, but the resulting nickel globule was even smaller yet than the preceding one. The silver contained in these coppers, being without influence to the processes, was neglected in the analyses.

It requires 36 hours in the spleiss furnace to refine the copper from the refining slag. The process in refining is somewhat different from that described above. The black coppers are roasted after warming for 12 hours, until in the last hour they slowly melt together. Then the proceeding is the same as above; but in the 30th hour the poling is commenced and repeated every half hour. The slag produced at last is very liquid and contains 63·5 per cent. of Cu.

The great amount of cobalt and nickel in these black coppers explains why it takes so much time to refine them. The oxides of cobalt and nickel, particularly the latter, form, with the oxides of antimony, a cover on the surface on the molten copper, through which the antimony cannot escape. The refining slags (abzüge) of this, as those of the preceding copper, are treated like those of the black copper of the amalgamation residues. The mattes hereby produced are worked up with the other mattes from the refining slags, (abzüge,) and the speiss is added to the speiss from the refining slags, (abzugsspeise.)

Working up of the (Abzugsspeiss) Speiss from the Refining Slags.— This is the last operation to be done. There are now in use for this purpose two methods, the "verlechung" (to melt them to matte,) and the extraction, or to extract the copper in the wet way. The proceeding with the first is equal to that of the "verlechung" of the roasted amalgamation residues of the speiss. The mattes are roasted and the speiss sold. But as the copper produced from these mattes was never of the quality of the others, the "extraction" was lately introduced.

For this purpose the speiss is stamped, and the coarse powder roasted in a reverberatory furnace of the same construction as those of the amalgamation, with addition of 10 per cent. of poor matte, and placed in quadrangular boxes, which have below a layer of birch brushes; over these a hurdle work of willows, covered by sheeting. Over these powders are pumped, first, a solution of common salt of 15° B., warmed to 180° to 200° Fahr., afterwards, the lye, deprived of copper, (see below,) which runs from the iron, until they are quite covered. The lye running from the powder boxes flows to a filter box, wherein the fine powder particles, which have been carried along with the current, separate, then through some boxes of fine granulated copper. These boxes have a depth of 3 feet, and are connected by pipes ascending from their bottom, so that the lye must sink through the layer of granulated copper, to ascend the pipe, and run into the next box From these it runs to the copper precipitating apparatus, a box 19

feet by 10 feet, and 1½ feet deep, divided by traverse planks in kennels 1 foot wide. The planks alternately leave a space of 2 inches between them and the walls of the box, so that the lye has to perform its way in zigzag. These canals are divided by boards, which stand alternately at a distance of 21 inches from the bottom and the upper level of the fluid, into cells 2 feet long, so that the lye has to ascend and descend in them. The first cells are filled by gray cast iron pieces, the last by sheet iron chips. The lye passing hot over the iron, the copper is rapidly precipitated, and the way over the iron need not to be so long as that in Schmöllnitz, where the fluid is cold, contains less copper, and must be deprived of every trace of the latter, because it is not used any more. From the sheet iron, the lye, deprived of its copper, runs to a reservoir, from which it is pumped again to the lye kettle, where so much common salt is added, as to return the lye to its former strength. Warmed it runs to the powders, which process is continued until the copper is extracted as much as possible. When the roasted materials contain silver, this is deposited in the first boxes, partly upon the granulated copper, partly on the cement copper. When argentiferous speiss is roasted to extract silver from it, 10 per cent. of salt are added in the lower hearth, but this is not necessary. The formation of chloride of silver and the solution of it are so perfectly performed by those substances containing much copper, that from the speiss of the refining slags (abzugsspeise) silver is precipitated, but it is necessary that the roasting of the powders in the first time is done in the lowest temperature, and every metallic particle destroyed, to expect a perfect extraction of the silver. There is no need to destroy the sulphuric acid salts, as in the amalgamation, where it must be done on account of the quicksilver. Here they are necessary to the process; therefore the fire is at last increased only to a dark-red heat, and very soon diminished, to draw out the charge an hour afterwards.

The Lye.—The speiss, roasted with matte, remains moistened 14 days to 6 weeks in a room, before it is put in the boxes for extraction, in which time copper and iron salts are formed. The decomposition is increased, when common salt or lye free from copper is added. These powders, containing sulphuric acid salts in great quantity, when extracted by a solution of common salt, and the filtered liquid evaporated by about 80° Fahr., give a salt crystallizing in cauliflower-formed yellow masses, (crystals.) This salt is everywhere visible in the extraction of the Stefanshütte on the powder boxes and the precipitating apparatus. After crystallization of this salt, by further evaporation, common salt crystallizes, which always must be in excess. At last green chloride of copper remains, containing not a trace of an iron salt. The yellow salt, covered with boiling water on a filter, yields an acid liquid, the residue on the filter contains soda, but by long and continuous washing with boiling water, pure ferric oxide at last remains. At 32° Fahr., glaubersalt crystallizes from the solution, and the fluid contains sesquichloride of iron and free acid. The crystals once formed, at a temperature below 32° Fahr., the yellow

salt appears not more during the process of evaporating at 80° Fahr., but crystals of glaubersalt. The specific weight of the lye has no influence on the formation of this latter, if the temperature is above 32° Fahr. To lye of 12° B., I added common salt until the specific gravity of it was 18° B., but in 8 days, at a temperature of 60° Fahr., nothing but gypsum crystallized from it, the lye of 12° B. gave, at 32° Fahr., large crystals of glaubersalt. The lye from the copper boxes running over iron, is by it deprived of its copper. After being warmed it passes again over the powder, and copper lixivates from them to commence the same circulation anew. Coming from the iron it contains only ferrous salt, and is almost without color. Exposed to the air it becomes turbid, basic salt is precipitated, and the color turns yellow. It has been the opinion that, free acid and ferric chloride being formed by this process, the lye obtained the capability to dissolve the copper in its different combinations in the roasted powders. The following experiment explains the process in the extraction boxes:

On a filter I treated roasted gray copper ores, free of iron and vein-stone, with boiling lye from the extraction, which, by digestion with sheet iron and some muriatic acid, was quite colorless and free of copper. The filtered lye, in getting cold, deposited small white crystals of subchloride of copper. Its color was green. It contained, therefore, both subchloride and chloride of copper, (cuprous and cupric chlorides.) The residue on the filter was a fine brown powder, and quite different in its aspect from that when a ferrous salt is precipitated by soda, and the precipitate oxidizes in the air. The residue on the filter consisted of ferric oxide, contained no silver, and only 2 per cent. of copper, so that the double salt containing ferrous oxide changes simply with the oxide of copper in the roasted powder, ferric oxide remaining, $3\,CuO + 2\,Fe\,Cl = Cu_2\,Cl + Cu\,Cl + Fe_2\,O_3$. If metallic copper is contained in the powders, this is dissolved, the cupric chloride being changed into cuprous chloride, the powders containing silver, the chloride of copper changes the silver into chloride, being reduced to subchloride of copper. Both are soluble in a solution of common salt; therefore it is necessary that the lye contains a great excess of salt, which must be added as soon as the white flat crystals of subchloride of copper appear on the mouth of the pipes leading to the boxes containing the granulated copper. The formation of the yellow salt explains why in summer, when no glaubersalt is formed, a loss of 6 lbs. of salt to 100 lbs. of speiss powder is endured. The above double salt is not perfectly decomposed by washing the speiss powders with hot water, and soda remains in them. In winter, when the lye, after the precipitation of the copper, is brought into a cold room, glaubersalt crystallizes, and it contains ferrous chloride, which changes to ferric chloride. Twice every week the copper is taken from the precipitating apparatus, the iron brushed off, to remove the carbonous matter, washed by water and put back to its place. The cement copper is washed by water, to separate the basic iron salts which the copper always contains. The residues, after being exhausted in this manner, contain yet 6 to 8 per cent. of copper. The resulting cement copper is melted in the spleiss furnace by addition of some upper

mattes, and, after they got spleissed and cold, put anew in the spleiss furnace, and refined in the ordinary way. In this manner copper of first quality is produced. When the residues, for the purpose of obtaining the copper from them, are roasted once more under addition of 10 per cent. of poor matte, and extracted as above, the precipitated copper has a more black color, the refined and toughened copper was falling to pieces. By forging under the hammer the composition is—

Refined and Toughened Copper from the Second Extraction of the Speiss from Refining Slags, Falling to pieces, Hammered Cold. Analysis by the Wet Way, Cu by Loss.

Sb	0·533
Ni	0·288
Cu	99·178
	100·000

Black Copper from the Refining Slags (Abzügen) of this Copper, (Crucible Grain,) Falling to pieces, Hammered Cold. Analysis by the Wet Way. Cu by Loss.

Ni	2·87
Sb	4·10
Cu	93·03
	100·00

From both of these analyses it is evident that the bad qualities of this copper are produced by an amount of nickel of not quite 0·3 per cent., by the combination of this nickel with antimony; while in the refined and toughened copper from amalgamation remains 1·01 per cent. of antimony, and in the copper from the refining slags, (abzugskupfer,) which is perfectly fit for a great many purposes, and even in demand, is 1·67 per cent. of antimony. It amounts in the copper of the second extraction to 0·533 per cent. only. The lye contains cobalt, (I succeeded to isolate it;) therefore first the silver, then copper, next the nickel, and finally the cobalt are dissolved by the lye, and again they are in the order, Ag, Cu, Ni, Co, precipitated by the iron, the two last, perhaps, in combination with antimony. The last 6 to 8 per cent. of copper are difficult to extract, and the resulting copper, as shown above, has such bad qualities that it neither can be sold, nor mixed with the other, because it spoils that, too; therefore to obtain the copper from these residues, it is necessary to melt them with pyrites, separate the antimony as metal, and to transfer the copper into matte. Such mattes are very poor. They contain only 5 to 8 per cent. of copper. They are roasted in 7 to 8 fires and added to other processes, as mentioned above. The speiss thus produced has the composition—

Crude Antimony Metal from the Residues of the Extraction of the Speiss from Refining Slags; Gray, Fine Grained, Produced July, 1862. Analysis by the Wet Way. Co. and Ni. Separated before the Blow-pipe.

Cu	13·20
Fe	13·68
S	3·33
Sb	67·45
Co	1·00
Ni	1·00
	99·66

Results of the Manipulation at the Stefanshutte.

	Ores delivered.					Average produced.				Consumed.		1 lb. copper produced with charcoal.
	Sparry.			Quartzy.		Yield in 100 lbs.		Spleissed Copper.	Fine Silver.	Charcoal.	Wood.	
	Ores.	Copper.	Silver.	Ores.	Copper.	Ag.	Cu.				Klf. a 100 Cu. ft. solid wood.	
	Cwt.	Cwt.	Mrk.	Cwt.	Cwt.	Ozs.	Lbs.	Cwt.	Mrk.	Cwt.		Lbs.
1855	73037	7920	5818	14162	679	0·63	9·85	7991	5758	92345	2550	11·55
1856	63708	6922	6326	17314	781	0·61	9 50	7755	5540	91506	2842	11·80
1857	54422	6136	6751	15480	630	0·99	9·67	7021	6595	73781	2530	10·50
1858	52108	5703	5095	15310	651	0·60	9·42	6755	5097	67970	2523	10·16
1859	53548	5957	4600	16437	709	0·68	9·53	7633	4950	75513	2444	9·87
1860	54119	6420	4788	17885	734	0·70	9·92	7792	4983	75446	2191	9·68
1861	53692	6467	4422	18578	794	0·65	10·14	7848	4847	72542	2141	9·24
1862	49189	5863	5221	16831	790	0 85	10·07	7729	5574	66579	2169	8·61

The same, produced February, 1863; *White, with Reflecting Surfaces. Assay before the Blow-pipe.*

Cu	6·8
Fe	4·5
S	2·0
Sb	84·7
Co	0·6
Ni	1·4
	100·0

The progress made in the manufacture of the crude antimony metal is evident from these analyses. While the first produced contained 13·68 per cent. of Fe, the quantity of it in the second was only 4·8 per cent., and the copper has fallen from 13·2 per cent. to 6·8 per cent.

The residues from the extraction of the speiss amount to 130 to 140 per cent. of it, (dry weight.) By the melting of them with 60 per cent. of kies, (pyrites,) not only a great quantity of charcoal is used, to reduce the oxides; but iron is introduced in the melting process, too, (precipitating iron and pyrites together almost the weight of the speiss,) so that in some cases it was necessary to use pure quartz, in want of poor quartzy ores. From both causes it is cheaper to melt the abzugsspeisse (speiss from refining slags) with pyrites, as stated above, and treat the produced mattes, as will be shown in the description of the processes of the Phönixhutte.

On National Standards for Gas Measurement and Gas-meters.

By George Glover, Esq.

From the London Journal of the Society of Arts, No. 424.

(Continued from page 123.)

The dry gas-meter has been brought to its present condition of excellence by successive stages. The essential improvements, invented by Mr. William Richards, and patented by Messrs. Croll and Richards in 1844, consisted in the introduction of the diaphragm and the direct action of the disk. The theoretical accuracy of the principles, which the invention of Mr. Richards involved, time and experience have fully established. The patentees, however, failed to reduce those principles to practice in producing a good and durable instrument, and they abandoned its manufacture. Mr. Croll having secured the patent, Mr. Thomas Glover, in 1845, commenced the manufacture of the meter, as Croll & Glover's patent dry gas-meter, and ultimately he manufactured it as his own, having from time to time introduced such improvements on the meter as experience pointed out to be necessary to render it a reliable gas-meter. To him belongs the merit of having imparted to Mr. Richards' invention a real and practical value by the production of a correct and durable instrument.

And here I may be allowed to refer to certain improvements made in the dry gas-meter by myself. The meter of Messrs. George Glover & Co. has a large and distinct dial, which shows at a glance the number of cubic feet of gas passed, the number of the meter's capacity per hour and per revolution, and the marks of identity, all of

which the "Sales of Gas Act" requires, the maker's name, and the date of the manufacture. These points of information are inscribed on an enamelled dial in legible and indellible characters; and they are necessary for reference, especially when disputes arise between buyer and seller, in which case the marks of identityand capacity are essential. These should not be entrusted to flimsy badges of thin metallic substances, which become tarnished and illigible, accidentally fall off, and can easily be transposed for fraudulent purposes.

A slot is introduced in our manufacture, and a pin which connects the valve and valve-rod. This facilitates the adjustment of the two sets of valves necessary to the uniform flow of gas, without which steady lights cannot be obtained. The attempt to adjust the position of the valve-pin by giving a curvature to the valve-arm is very objectionable. The valve-arm has to be made soft, so as to admit of this finger and thumb adjustment, its protracted immersion in gas rendering it still softer. The result is that the rod becomes more or less curved during the action of the meter as it transmits force, in the direction of its length, as a thrust or as a pull alternately.

Another improvement I have effected is the introduction of a slot in the tangent of the meter, and the placing a shoulder or rest on the tangent pin, the flat surface of which rests on the upper surface of the tangent. The pin is secured in its place by a screw from below, the flattened head of which fixes it firmly at any desired point of the slot. This arrangement keeps the pin in a perfectly vertical position, and admits of the meter being registered with care and precision. To secure uniformity we stamp the cases and internal parts of our meters. This we do by steam power, and we are thereby enabled to effect a saving in their production.

To reduce to practice the idea of a machine for the accurate measurement and correct registration of gas the experience of half a century has shown to be no easy problem. The construction of a good and durable dry gas-meter involves a multiplicity of chemical and mechanical considerations, to each of which its due weight must be assigned.

As I said, when speaking of the standards, a subtle, invisible, elastic, aëriform body, very complex in its chemical constitution, susceptible of change in condition and volume from slight variations in temperature and pressure, has to be accurately measured, and the result of that measurement must be accurately recorded. The instrument must be self-acting, and must act in a closed chamber, continuously or at intervals, requiring no adjustment or interference of any kind. All its parts which come in contact with gas must be made of anti-corrosive metal; while the materials, forms, and combinations of its different parts must be so arranged and so adapted to each other that, when put together as a whole, it shall work easily, steadily, and correctly.

Many have a strong prejudice against using leather in dry gas-meters. This prejudice is well-founded when the leather is not properly prepared for gas, or when it is used as a hinge for the doors of the measuring chambers in meters of oblique action, when it is liable to

give way. But when it is properly prepared for the reception of gas, which contains carbolic acid or creosote—an excellent antiseptic for animal texture—and its flexibility is used to a limited extent, it will remain sound and pliable for any length of time. The dry gas-meter, in fact, obviates, I respectfully submit, all the objections to the wet meter. I may be allowed to state *seriatim* its different points of superiority.

1. It measures accurately, and does not vary in its registration.

2. It does not cause jumping, or sudden extinction of the lights, the former a common source of annoyance, the latter not free from danger, especially in large assemblies, and on railway lines where signal lights are used.

3. It does not require to be opened that water may be put into it; thus escape of gas from the plugs being carelessly left open, always offensive, and occasionally producing explosions, are averted.

4. It cannot be tampered with without showing distinct evidence of having been so; and it is thus free from the many temptations and facilities to fraud which are characteristic of the wet meter.

5. It does not allow the gas to pass without being registered, a source of much greater loss to companies than is commonly supposed, and which is caused by the water-level falling to a point at which the gas passes unregistered.

6. The frequent supply of water now rendered necessary by the small range of error allowed by the "Sales of Gas Act," the vigilant attention required to prevent fraud, and to ascertain when the gas is passing unregistered, need three times the number of inspectors requisite where dry meters are used; whilst in testing meters the expense of inspectors and instruments is three times as great with the wet as with the dry meter, which thus effects a great saving to gas companies and to local authorities.

7. The dry meter does not require to be placed in the basement or lower part of the house, but may be put anywhere. The attempt with wet meters to prevent jumping of the lights by giving all the pipes a gradual ascent to the meter, so as to admit of the water trickling back into it, besides being impracticable, is expensive and detrimental to house property.

8. The dry meter works with less pressure than the wet. Not only is a saving of gas thus affected, but in large cities where, during the winter season, dense fogs occur, the low pressure in the mains during the day is not adequate to move the wet meters so as to supply enough of gas for the burners, and only small smokey flames can be obtained from them, but with the dry meter under all these circumstances there is sufficiency of light. Thus interruptions to business are averted.

9. The action of the dry meter cannot, like that of the wet, be arrested by frost, causing total extinction of the lights. This makes the dry meter especially advantageous on railway lines, precluding, as it does, the necessity of keeping up fires near the meter during a severe and protracted frost. This applies with peculiar force to countries

where the cold is intense, and where the evil is attempted to be combated by putting spirits or glycerine into the meter.

10. Made of anti-corrosive metal, and not subject to the corrosive power of the chemical constituents of coal-gas and water, the dry meter is a much more durable instrument than the wet.

Coal-gas, like water, has become a necessary of life. It is so, more especially in large towns. Its superiority over all other materials for producing light is acknowledged, and the general and persistent demand of the public for gas at a lower price, and of higher illuminating power, has induced gas companies again and again to lower its price; some to a point at which it is vain to expect profit so long as a loose system of measurement prevails, and one-fourth or one-fifth part of the whole quantity produced is allowed to go to waste, and is not paid for. Coal is becoming dearer; labor more expensive. And the question arises—How are dividends to be maintained or improved and the enormous capital sunk in gas properly protected? The coal cannot be made to produce more gas. Improvements and economy in its manufacture and distribution have nearly reached their limit. The pipes now are more solid than they used to be, while their increased size has enabled the companies to distribute their gas at a lower pressure. The joints, services, and fittings have been rendered much sounder and more perfect, so that, in gas-works which are properly managed, the actual loss by leakage is probably less than five per cent. And it is daily becoming more apparent that, if gas is to be produced at a remunerative rate, the present loose system of measurement must cease, and imperfect meters must give place to others which are reliable.

Mr. Alex. McIvor said they were all indebted to Mr. Glover for his able paper, and he had no doubt scientific men would admit that he had done them service, as well as the proprietors and managers of gas-works, in drawing attention to the subject of gas measurement. It had hitherto been a matter of great difficulty to find the means of accurately measuring gas, and this was only to be arrived at by the most delicate and carefully constructed apparatus. It must be admitted that great success had attended Mr. Glover's labors, for he had given a degree of accuracy and precision to the art of gas measuring which was previously unknown. The gasometers previously in use for testing meters were most imperfect and unsatisfactory, and presented a great many difficulties to gas managers. He had been shown by one manager a gasometer which he employed for this purpose, consisting simply of a bell suspended by a string over a pully. It was painted green, and when pulled out of the water it was covered with wet. It was unnecessary to point out how imperfect such a measuring instrument as that must be. It was to be regretted that many gas managers were but slightly acquainted with the nature of the process they carried on. Until they got suitable instruments, however, it could in no case be expected that they would do the work properly. The perfection to which the art of gas making and distribution was now brought reflected great credit on the country, and the importance of the manufacture

might be estimated by the fact that the consumption of gas in this kingdom amounted to £6,000,000 sterling annually.

Mr. Chaney said, as an officer of the Exchequer, he begged to thank Mr. Glover for his valuable paper. He wished at the same time to remind the meeting how much they were indebted to Professor Airey, whose name had been so prominently mentioned in the paper, for his labors on this subject. He had devoted much of his valuable time, for a period of thirty years, to the restoration and preservation of our standard weights and measures. They were also indebted to Mr. George Lowe, a famous gas engineer, for the introduction of the decimal system in gas measurement; and to Dr. Frankland, for his valuable investigations into the chemical and physical constitution of gas.

Mr. E. H. Thorman regretted that no manufacturer of wet meters had risen in their defence. He could not quite agree with the sweeping condemnation that had been passed upon those instruments. It was a long time before he became a convert to dry meters. He knew that the public would now, if possible, have dry meters, but he thought the complaints against wet meters were more than experience and practice justified. He believed that the bad cases of error that had been brought forward were quite exceptional, and he regards the wet meter as being very beautiful in its mechanical operation, and in every way worthy of the support of the gas companies.

Mr. C. F. T. Young considered that the defects of the wet meter had not been dwelt upon too strongly, as they immediately became manifest on inspecting one which had been a long time in use. There was a constant antagonism going on between the materials—iron and brass—of which the mechanical portion of the instrument was formed, and the water in which it worked, and destruction of the parts necessarily ensued. When they reflected upon the fact that so small a difference of level in the water as a quarter of an inch very materially affected the discharge of the gas from the meter, it would be seen how important it was, both to the consumer and the manufacturer, that an instrument not liable to such imperfections should be employed. He had heard it asserted by persons well informed on the subject, that wet meters had even been found to register incorrectly to the extent of 60 per cent. In the cases of 36 meters, taken indiscriminately, the register was found to be invariably incorrect, being in some cases against the consumer, and in others against the gas company. The dry meter certainly removed many of the objections which attached to the wet meter, and which were inherent to the principle on which it was constructed, and in his opinion the former was certainly much to be preferred.

Mr. F. W. Hartley said he stood there as an impartial individual, inasmuch as he was interested in the manufacture of both wet and dry meters. He admitted the truth of Mr. Glover's observations, but with some limitation. They were led to believe that the wet meter as now made was liable to grave and serious errors, both against the manufacturer and the consumer. He thought that could hardly be the case. The tilting of the meter in the way described by Mr. Glover could

hardly be carried on to any considerable extent without being detected by the inspecting officer of the company, on the one hand, or by the consumer on the other. The variation in the level of the water was permitted to the extent of 5 per cent.—2 per cent. against the consumer and 3 per cent. against the company. Protection was given to the consumer by a self-acting arrangement which shut off the supply as soon as the point was reached, which gave a register of 3 per cent. in favor of the company. He had inspected many hundreds of wet meters, but had never found such a variation as had been mentioned in the paper. As to the question of pressure, he denied that it had any effect upon the registration of the meter unless in connexion with increased speed of the measuring wheel. This, indeed, he had tested, for some years ago he had occasion to make experiments on this point, and he found that working a meter at something like one-tenth of its speed, and trying it up to five times the proper speed, only effected a variation of two to three per cent. Evaporation was an objection which told most against the wet meter, and was one on which its opponents dwelt very strongly, and there certainly was inconvenience from this at times. It was stated that the combination of different metals introduced into wet meters tended to rapid destruction; but they had practical evidence of the long duration of these meters. If there was that violent galvanic action which had been referred to, the meters would long since have been destroyed, and would have gone out of use, because the public would have found them not durable. He therefore thought they were justified in assuming that the wet meter was not so disadvantageous as it had been represented to be. Mr. Glover was mistaken in supposing that all gas-holders were measured by the transferrer previous to the passing of the Sales of Gas Act. He knew that at the present time there were gas-holders that had been graduated by the exact weight of water previously to the passing of that act; and nothing could be more accurate. There was less difference between them and the Exchequer standards than was permitted by the Act. He had nothing to say against the dry meter, but he believed that both that and the wet instrument were capable, if fairly used, of doing equal justice to the consumer and the company. If a wet meter were tilted in an unfair manner, they could not expect it to register correctly. It was as absurd to expect this as to place a clock on a shelf out of level and expect the pendulum to act.

Mr. Defries, as a manufacturer of meters with an angular motion, justified that form of construction, on the ground that it did not carry condensation, but threw off the condensed matter, and deposited it at the base of the meter, where it could always be drawn off without disturbing the meter itself. The notion that the leather of the diaphragm was injuriously affected by the action of the gas upon it was, he said, entirely erroneous.

Mr. Bishop, speaking only in the character of a gas consumer, expressed himself decidedly in favor of the dry meter.

The Chairman would now ask the meeting to accord their thanks to Mr. Glover for the very interesting paper he had read, and in doing

so he would for a moment consider the position in which this question had been placed before them. He took exception to one or two remarks made in the paper: First, as to the duty of the government in matters of this kind; and, in the next place, the statement that gas-works were not a nuisance to neighborhoods in which they were placed. As to the duty of the government, he dissented entirely from the view that it was the function of government to interfere with manufacturers of any kind, whether gas-meters or anything else. It devolved upon the consumer to look after his own interests and to employ that meter which he believed to be most just, both to himself and to the gas company.

Mr. Glover explained that he had not advocated that the government should interfere with manufacture, but should merely give every facility for the production of gas, as conducing to the public welfare. He entirely concurred in the views expressed by the Chairman as to the importance of the non-interference of government with trade or manufacture.

The Chairman, having quoted the paragraph of the paper which had prompted his remark, went on to say, he did not hold it was the duty of the government to interfere with manufactures in any way, and he did not know how they could "protect or encourage" without some sort of interference. He believed the real interests of commerce and of the progress of invention in this country were dependent upon the fullest and most unfettered employment of ingenuity and capital, and that government protection or interference of any kind was an evil. As regarded gas-works, he could not agree that it was desirable they should be placed in the centres of great towns. True, the recent accident which occurred at one of these works might have been prevented by proper precautions, but was there any accident which might not have been prevented by due and proper care? The question was, Were not gas-works subject to special kinds of accidents, and in the present day ought such elements of danger to be placed in the centres of large populations? He contended that the sooner such evils could be removed, without injustice to those who had invested their capital in them, the better. The paper opened the question as to which was the best instrument for measuring gas as it was delivered from the mains for the use of the consumer. He thought the relative merits of the wet and dry meter depended upon this, Which of the two instruments was composed of the most durable materials? In the one case, they have metallic mechanism working in water impregnated with ammonia, while the other meter was dependent upon the durability and elasticity of the leather diaphragm. It appeared to him, taking the facts as they stood on both sides, looking also at what had fallen from the speaker, who was a manufacturer of both kinds of meters, and judging from experience, the evidence seemed certainly to be in favor of the dry meter, as opposed to the wet, which required a very large amount of attention to secure accurate working. Without condemning the wet meter, which was certainly a most ingenious instrument, he thought that when they looked at the admirable contrivances

and beautiful workmanship which were introduced into the dry meters on the table before them, they must incline to the opinion that more permanent accuracy could be obtained by the latter instrument. He was sure they would feel that they were much indebted to Mr. Glover for the manner in which he had brought this subject under the notice of the Society, and he begged to propose a cordial vote of thanks to that gentleman for his paper.

The vote of thanks was unanimously passed.

Mr. Glover, in acknowledging the compliment, observed that he thought nothing had been said in the discussion to invalidate the statements made in his paper.

Measures of Length, Capacity, and Weight.

Among the important acts passed at the last session of the Congress of the United States, there are three to which we wish to call the attention of our readers, in consequence of their great importance to the commerce and industry of our country. One of the earliest efforts of our government, after the establishment of our independence, was to draw closer the bonds of union between different civilized nations, by bringing about the use of common standards for all purposes of international intercourse. The attention of Mr. Jefferson, as Secretary of State, was, at an early period, directed to this object, and it may be said that from that time to this our government has never lost sight of this object, and never ceased to labor for its accomplishment. The bold and successful adoption, by the French revolutionary government, of a new and rational set of measures, which were all connected together, and subjected to the simple decimal system of division, although it appeared at first to increase the existing confusion by adding one more to the numerous systems in use, yet in reality first rendered uniformity practicable by presenting a system, which, although probably not the best possible in conception, was still far superior to any in use: and this movement has resulted in the gradual adoption of the metrical system by many of the European nations, and its legal recognition and toleration by almost all. Perhaps the reluctance to adopt this system in this country arose as much from the American tendency to the best possible, as to the fact that our chief intercourse was with England, which, with characteristic obstinacy, held out against any change of her onerous and absurd collection of standards. When, therefore, the English Parliament yielded and legalized, in the British dominions, the French metrical system, we, on this side of the Atlantic, were compelled to follow; because it has become evident that, whatever theoretical advantages other systems may have, the metrical system is the best one whose general adoption is possible. In view of this the United States Congress, at its last session, passed a series of Acts, the intention and result of which is to legalize the use of the French metrical system in this country, and to establish the ratios for the conversion of our ordinary standards into the French, and *vice versa*. We give these Acts in full, on account of their importance, and shall, in a

future number, give a series of tables for the conversion of one set into the other, which we hope our readers will find useful to them.

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JOINT RESOLUTION

To enable the Secretary of the Treasury to furnish to each State one set of the standard weights and measures of the metric system.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and he is hereby, authorized and directed to furnish to each State, to be delivered to the Governor thereof, one set of the standard weights and measures of the metric system for the use of the States, respectively.

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AN ACT

To authorize the use in post offices of weights of the denomination of grams.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Postmaster-General be, and he is hereby, authorized and directed to furnish to the post offices exchanging mails with foreign countries, and to such other offices as he shall think expedient, postal balances denominated in grams of the metric system; and, until otherwise provided by law, one-half ounce avoirdupois shall be deemed and taken for postal purposes as the equivalent of fifteen grams of the metric weights, and so adopted in progression; and the rates of postage shall be applied accordingly.

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AN ACT

To authorize the use of the metric system of weights and measures.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the passage of this Act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 2. *And be it further enacted*, That the tables in the schedule hereto annexed shall be recognised in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system.

Measures of Surface.

Metric denominations and values.		Equivalents in denominations in use.
Hectare.....	10,000 square meters.	2·471 acres.
Are.....	100 square meters.	119·6 square yards.
Centare.....	1 square metre.	1550 square inches.

Measures of Capacity.

METRIC DENOMINATIONS AND VALUES.			EQUIVALENTS IN DENOMINATIONS IN USE.	
Names.	Number of liters.	Cubic measure.	Dry measure.	Liquid or wine measure.
Kiloliter, or stere...	1000	1 cubic meter,.....	1·308 cubic yards.....	264·17 gallons.
Hectoliter.....	100	$\frac{1}{10}$ of a cubic meter	2 bushels and 3·35 pecks.	26·417 gallons.
Dekaliter	10	10 cubic decimeters	9·08 quarts.....	2·6417 gallons.
Liter.....	1	1 cubic decimeter.....	0·908 quart.....	1·0567 quart.
Deciliter.....	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic decimeter....	6·1022 cubic inches.....	0·845 gill.
Centiliter.....	$\frac{1}{100}$	10 cubic centimeters.....	0·6102 cubic inch.....	0·338 fluid ounce.
Milliliter.....	$\frac{1}{1000}$	1 cubic centimeter	0·061 cubic inch,..	0·27 fluid dram.

Measures of Length.

Metric denominations and values.		Equivalents in denominations in use.
Myriameter.....	10,000 meters.	6·2137 miles.
Kilometer.....	1,000 meters.	0·62137 miles, or 3280 feet 10 inches.
Hectometer.....	100 meters.	328 feet 1 inch.
Dekameter.....	10 meters.	393·7 inches.
Meter.....	1 meter.	39·37 inches.
Decimeter.....	$\frac{1}{10}$ of a meter.	3·937 inches.
Centimeter.....	$\frac{1}{100}$ of a meter.	0·3937 inch.
Millimeter.....	$\frac{1}{1000}$ of a meter.	0·0394 inch.

Weights.

METRIC DENOMINATIONS AND VALUES.			EQUIVALENTS IN DENOMINATIONS IN USE.
Names.	Number of grams.	Weight of what quantity of water at maximum density.	Avoirdupois wt.
Millier, or tonneau.	1,000,000	1 cubic meter.....	2204·6 pounds.
Quintal.....	100,000	1 hectoliter.....	220·46 pounds.
Myriagram.....	10,000	10 liters.....	22·046 pounds.
Kilogram, or kilo...	1,000	1 liter	2·2046 pounds.
Hectogram	100	1 deciliter.....	3·5274 ounces.
Dekagram.....	10	10 cubic centimeters	0·3527 ounce.
Gram	1	1 cubic centimeter.	15·432 grains.
Decigram.....	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic centimeter..	1·5432 grains.
Centigram	$\frac{1}{100}$	10 cubic millimeters.....	0·1543 grain.
Milligram.....	$\frac{1}{1000}$	1 cubic millimeter.....	0·0154 grain.

Recent Progress in the History of proposed Substitutes for Gunpowder. By PROF. F. A. ABEL, F.R.S., V. P. C. S., Chemist to the War Department.

From the London Chemical News, No. 344.

The changes which have been effected in the composition of gunpowder, since its first application as a propelling agent, have been limited to small variations in the proportions of its constituents. But the modifications which have from time to time been introduced into the details of manufacture, *e.g.*, the preparation of the ingredients, their incorporation, and the conversion of the mixture into compact masses (grains, &c.) of different size and density, have been sufficiently important and successful to secure the fulfillment by gunpowder, in a more or less efficient manner, of the very various requirements of military science and of different branches of industry.

The characteristics of gunpowder, as an explosive material of permanent character, the action of which is susceptible of great modifica-

tion, are mainly ascribable to the peculiar properties of the oxidizing agent—saltpetre. Frequent attempts have been made to replace this constituent of gunpowder by other nitrates, (such as those of sodium, lead, and barium;) but, although materials suitable for blasting operations have been thus prepared, (such as soda-gunpowder, and barytic powder, or *poudre saxifragine*,) all mixutres of this class hitherto produced have exhibited important defects, when compared with gunpowder manufactured for propelling purposes.

The well-known oxidizing agent, chlorate of potash, which differs from saltpetre only in containing chlorine in the place of nitrogen, is far more energetic in its action upon oxidizable bodies than any of the nitrates. Thus, a mixture of chlorate of potash with charcoal alone deflagrates as violently as gunpowder, and is far more readily inflamed by percussion than the latter; while a mixture analogous to gunpowder, containing chlorate of potash in place of saltpetre, detonates violently when struck with moderate force, and acts far too destructively, on account of the rapidity of its explosion, to admit of its safe employment in fire-arms.

Many years ago, a mixture known as German, or white, gunpowder, and consisting of chlorate of potash, ferrocyanide of potassium, and sugar, was proposed and tried without success as a substitute for gunpowder; and since then many preparations of a similar character have been suggested for employment either as blasting and mining agents, or for use in shells, or even for all the purposes to which gunpowder is applied. The most promising of these, claimed as discoveries by Mr. Horsely and Dr. Ehrhardt, are mixtures of chlorate of potash with substances of permanent character and readily obtained, containing both carbon and hydrogen, such as tannic and gallic acids, and some kinds of resins. These mixtures are much less violently detonating than most of the explosive mixtures containing chlorate of potash, while, if well prepared, they are decidedly more powerful as explosives than gunpowder. For blasting purposes some of these mixtures probably possess decided advantages over ordinary blasting powder, and possibly they may also be susceptible of employment for sporting purposes; but they are not applicable to fire-arms used for war purposes, because, in order to ensure the requisite uniformity of action, the ingredients must be submitted to proper processes of incorporation, &c., such as are applied to the manufacture of gunpowder; and this treatment would render the mixtures far more violent, and consequently destructive, in their action upon fire-arms, than if used in the form of crude mixtures.

A comparatively very safe application of chlorate of potash to the production of a substitute for gunpowder was made about six years ago by a German chemical manufacturer, M. Hochstädter. Unsized (blotting) paper was thoroughly soaked in, and coated with, a thin paste consisting of chlorate of potash, finely divided charcoal, a small quantity of sulphide of antimony, and a little starch, gum, or some similar binding material, water being used as the solvent and mixing agent. The paper was rolled up very compactly and dried in that form.

In this manner, very firm rolls of an explosive material are obtained, which burns with considerable violence in open air, and the propelling effect of which, in small arms, has occasionally been found greater than that of a corresponding charge of rifle powder. Moreover, the material, if submitted in small portions to violent percussion, exhibits but little tendency to detonation. But as no reliance can be placed on a sufficient uniformity of action, in a fire-arm, of these explosive rolls, this alone sufficed to prevent their competing with powder. The same description of explosive preparation, differing only from that of M. Hochstädter in a trifling modification of its composition, which is certainly not likely to lead to its greater success, has recently been brought forward in this country by M. Reichen and Mr. Melland.

One or two other much cruder explosive preparations, containing chlorate of potash, alone or in conjunction with saltpetre, have met with some application to blasting purposes. One of these consisted of spent tan, in small fragments, which was saturated with the oxidizing agent, and afterwards dusted over with sulphur. When flame or a red-hot iron is applied to this preparation, it deflagrates very slowly and imperfectly; but when employed in blast holes, where it is confined within a small space, it develops sufficient explosive force to do good work. In addition to comparative cheapness, the great advantage of safety was claimed for this material by its inventor, a claim which was substantiated by the partial destruction by fire, on two occasions, of a manufactory of the substance near Plymouth, without the occurrence of an explosion.

The accidental explosions of gunpowder which are occasionally heard of, occur, in most instances, at the manufactories, and in the course of some operation (especially that of incorporation) to which the explosive mixture is submitted. The only means of guarding against, or reducing as much as possible, the liability to the occurrence of these accidents, consist in the strictest attention to the precautionary measures and regulations, which experience has proved to be essential to safety, and which, in spite of the strictest supervision, are unquestionably sometimes overlooked or imperfectly carried out by workmen. Explosions of gunpowder, generally of a serious character, do occur, however, though very rarely, during the transport of the material, or in magazines where it is stored. The great explosion of a gunpowder magazine at Erith in September, 1864, specially directed the attention of government and the public generally to the necessity of adopting measures for reducing, as much as possible, the risk of occurrences of such disastrous accidents. Hence, much interest has recently been excited by a well-known method of rendering gunpowder less dangerous in its character, which has been brought prominently before the public by Mr. Gale, and which consists of diluting powder, or separating its grains from each other, by means of a finely powdered non-explosive substance. Attempts have several times been made in past years to apply to practical purposes the obvious fact, of which nobody acquainted with the nature of gunpowder could be ignorant, that, by interposing between the grains of powder a sufficient quantity of a finely

divided material, which offers great resistance to the transmission of heat, the ignition of separate grains of the entire mass may be accomplished without risk of inflaming contiguous grains. In 1835, Piobert made a series of experiments with the view to apply this fact practically to reduce the explosiveness of gunpowder, and similar experiments of an extensive character were carried on by a Russian chemist, Fadéiff, between 1841 and 1844. These experimenters found that the object in view might be attained by diluting gunpowder with any one of its components; they also employed very fine sand, (a substance closely allied in its physical characters to the powdered glass which Mr. Gale now proposes to use;) but the preference appears to have been given to a particular form of carbon. It was not attempted altogether to prevent the burning of a mass of gunpowder when a spark or flame reached any portion, but to reduce the rapidity of combustion so greatly as to prevent the occurrence of a violent explosion. No more than this is accomplished by the employment of powdered glass in the proportions directed by Mr. Gale. Indeed, as the quantity of diluent required to give to different kinds of gunpowder the character of equally slow burning materials, increases with the explosiveness of the particular powder and with the size of its grain, the proportion of powdered glass with which the gunpowder employed in rifled cannon would have to be mixed to render it only slow burning, would be about double the quantity required for almost altogether preventing the ignition of fine grain powder, or of the comparatively weak blasting powder with which Mr. Gale's public experiments appear generally to have been instituted. Although a sufficient dilution of gunpowder may secure such comparative safety to the neighborhoods of large magazines, or to the crews of merchant vessels in which gunpowder (for blasting purposes, &c.) is transported, as to compensate fully for the inconvenience attending the great increase of volume of the powder, there is no doubt that such a treatment of gunpowder actually issued for military and naval service would be attended by more than one serious obstacle—such as the tendency of the powder, unless very largely diluted, to separate from the glass, during transport by land or sea, to so considerable an extent as very greatly to diminish the degree of security originally aimed at; the very great addition which would have to be made to the arrangements for carrying the necessary ammunition in active service; the necessity for introducing, in the field or on board ship, the operations of separating the powder from the glass and transferring it to cartridges and shells, (which, whatever sifting and other arrangements were adopted, would be time-taking and very dangerous,) instead of preserving the ammunition ready for immediate use; and, above all, the incalculable mischief which would inevitably result from the establishment, in the minds of the soldier and sailor, of an erroneous feeling of security in dealing with gunpowder, which, however harmless it may for a time be rendered, must finally be handled by the men in its explosive form. The extremely rare occurrence of accidents with gunpowder, on board ship or in active land service, is mainly due to the strictest enforcement of precaution-

ary regulations, some of which may appear at first sight exaggerated or almost absurd, but which combine to maintain a consciousness of danger and a consequent vigilance indispensable to safety.

One of the most remarkable materials recently employed to replace gunpowder as a destructive agent is nitro-glycerine. This substance was discovered by Sobrero in 1847, and is produced by adding glycerine in successive small quantities to a mixture of one volume of nitric acid of sp. gr. 1·43, and two volumes of sulphuric acid of sp. gr. 1·83. The acid is cooled artificially during the addition of glycerine, and the mixture is afterwards poured into water, when an amber-colored, oily fluid separates, which is insoluble in water, and possesses no odor, but has a sweet, pungent flavor, and is very poisonous, a minute quantity placed upon the tongue producing violent headache which lasts for several hours.

The liquid has a sp. gr. of 1·6, and solidifies at about 5° C., (40° Fahr.) If flame is applied, nitro-glycerine simply burns, and if placed upon paper or metal, and held over a source of heat, it explodes feebly after a short time, burning with a smoky flame. If paper moistened with it be sharply struck, a somewhat violent detonation is produced. Alfred Noble, a Swedish engineer, was the first to attempt the application of nitro-glycerine as an explosive agent, in 1864.

Some experiments were, in the first instance, made with gunpowder, the grains of which had been saturated with nitro-glycerine. This powder burnt much as usual, but with a brighter flame in open air. When confined in shells or blast holes, greater effects were, however, produced with it than with ordinary gunpowder; its destructive action is described as having been from three to six times greater than that of powder. The liquid could not be employed as a blasting agent in the ordinary manner, as the application of flame to it from a common fuze would not cause it to explode. But Mr. Noble has succeeded, by employing a special description of fuze, in applying the liquid alone as a very powerful destructive agent. The charge of nitro-glycerine having been introduced, in a suitable case, into the blast hole, a fuze, to the extremity of which is attached a small quantity of gunpowder, is fixed immediately over the liquid. The concussion produced by the exploding powder upon the ignition of the fuze effects the explosion of the nitro-glycerine.

The destructive action of this material is estimated, by those who have made experiments in Sweden and Germany, as about ten times that of an equal weight of gunpowder. Therefore, although its cost is about seven times that of blasting powder, its use is stated to be attended with great economy, more especially in hard rocks, a considerable saving being effected by its means in the labor of the miners, and in the time occupied in performing a given amount of work, as much fewer and smaller blast holes are required than when gunpowder is employed. The material appears to have recently received considerable application in some parts of Germany and in Sweden; but in England its employment has been confined to one set of experiments instituted in Cornwall last summer, upon which occasion a wrought

iron block, weighing about three hundred-weight, was rent into fragments by the explosion of a charge of less than one ounce of nitro-glycerine placed in a central cavity.

Nitro-glycerine appears, therefore, to possess very important advantages over gunpowder as a blasting and destructive agent, but the attempts to introduce it as a substitute for gunpowder have already been attended by most disastrous results, ascribable in part to some of its properties and the evident instability of the commercial product, but principally to the thoughtlessness of those interested in its application, who appear to have been induced, either by undue confidence in its permanence and comparative safety, or from less excusable motives, to leave the masters of ships or others who had to deal with the transport of the material, in ignorance of its dangerous character.

The precise causes of the fearful explosions of nitro-glycerine which occurred at Aspinwall and San Francisco will, in all probability, never be ascertained; but they are likely to have been due, at any rate, indirectly to the spontaneous decomposition of the substance, induced or accelerated by the elevated temperature of the atmosphere in those parts of the ship where it was stored. Instances are on record in which the violent rupture of closed vessels containing commercial nitro-glycerine has been occasioned by the accumulation of gases generated by its gradual decomposition; and it is, at any rate, not improbable that a similar result, favored by the warmth of the atmosphere, and eventually determined by some accidental agitation of the contents of the package of nitro-glycerine, was the cause of those lamentable accidents. The great difficulties attending the purification of nitro-glycerine upon a practical scale, and the uncertainty, as regards stability, of the material even when purified, (leaving out of consideration its very poisonous character and its extreme sensitiveness to explosion by percussion when in the solid form,) appear to present insurmountable obstacles to its safe application as a substitute for gunpowder.

(To be continued.)

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, September 19th, 1866.

The meeting was called to order with the Vice-President, Prof. Fairman Rogers, in the chair.

The minutes of the last meeting were read and approved.

The Board of Managers presented their minutes and reported the following donations to the Library:

From the Royal Astronomical Society, the Royal Geographical Society, the Society of Arts, the Chemical Society, the Statistical Society, and the Institute of Actuaries, London, England; Thomas Oldham, Superintendent of the Geological Survey of India, Calcutta, India; la Sociétié d'Encouragement pour l'Industrié Nationale, l'Ecoles des Mines,

l'Academie des Sciences, Paris, and la Société Industrielle, Mulhouse, France; the Oesterreichischen Ingenieur-Veriens and the K. K. Geologischen Reichsanstalt, Vienna, Austria; Major L. A. Huguet-Latour, Montreal, Canada; the Commissioner of Patents, the Commissioner of Agriculture, and Hon. Edgar Cowan, U. S. Senate, Washington, D. C.; the Ohio Mechanics' Institute, Cincinnati, Ohio; the Managers of the State Lunatic Asylum, Utica, New York; and Wm. Milnor Roberts, Esq., Frederick Fraley, Esq., and the American Philosophical Society, Philadelphia.

The various Standing Committees reported their minutes, and the Special Committee on Experiments in Steam Expansion reported progress.

The following resolution was then proposed by Mr. George Erety, and was duly seconded and carried:

Resolved, That the President shall appoint a committee of five members of the Institute, whose duty it shall be to obtain and collect information and facts relative to the early organization of the Franklin Institute, and the causes that led thereto, the state of the American mechanic arts at the period of said organization, the influence of the Institute thereon, and the progress made in said arts, and the sciences connected therewith, since that time. With such matters in relation to, and the present state of the Institute, as in their judgment may be useful. And that said Committee shall be authorized to have prepared for publication the information and facts on the subject so obtained and collected.

The following named gentlemen were appointed by the President of the Institute, in accordance with the above resolution: Samuel V. Merrick, Chairman; Fred. Fraley, John C. Cresson, John F. Frazer, George Erety.

Secretary's Report.

ENGINEERING WORKS, &c.—The Sand Patch tunnel on the Pittsburgh and Connelsville Railroad is at last cut through. Its total length is 4750 feet, being 1000 feet more than the long tunnel on the Pennsylvania Central Railroad through the Alleghanies between Altoona and Cresson. It is intended for a double track, and is 22 feet wide by 19 feet in height.

The sewage pumps at Crossness.—In the new system of drainage applied to London, a large amount of the sewage matter collects at a level, requiring the use of pumps to remove it. To meet this demand a system of engines, &c., have been established at Crossness, by which this matter is raised 19 feet 6 inches, and thrown into a reservoir constructed for its reception. This reservoir covers an area of 6½ acres, is 14 feet deep, and has a capacity of 24,000,000 gallons. It is arched over with brick-work, supported on 644 piers, and is covered with earth and sod.

It is usual to discharge this reservoir into the river about half an hour before high tide, but during heavy rains it is filled and emptied four times in the 24 hours.

The engines are 4 in number, each working 8 pumps, which are of the usual plunger construction; their aggregate capacity amounts to 29,523 gallons per minute. The minimum amount raised in 24 hours is 38,000,000 gallons, the maximum 100,000,000 gallons.

Traction engines for common roads have been put successfully in operation in two places. One of these, constructed by Dübs & Co., of Glasgow, for use in Syria, on the road between Damascus and Beyrout, was tried near the place of its manufacture and attained an average speed of 4½ miles per hour, the maximum being 6 miles, with a load of 10 tons.

A gold medal of the first class was also awarded to Albert & Co., of Liancourt, by the Minister of Public Works, for a traction engine drawing a load of 5 tons with a maximum speed of 5 miles per hour and an average of three and a half.

PHYSICS, Light.—Improvements in lime-lights, by Robert Grant, 246 Canal Street, New York.

All who have used the lime-light for a long time are well aware of the inconveniences which attend the employment of india rubber gas-bags as reservoirs for one or both of the gases. Their rapid deterioration, liabily to injury in transportation, whether full or empty, leakage, unwieldiness, and cost, are all drawbacks fully realized by all concerned. The advantages of the new plan, as regards the matter of reservoirs, will then be clear on simple inspection. In this, iron cylindrical reservoirs, 9 inches in diameter by 30 in length, and having therefore a capacity of about one cubic foot, are made so strong as to bear with perfect safety a pressure of 30 atmospheres, but yet weigh only 26 pounds. These are charged by means of condensing pumps, with the gases required up to the pressure named, when each will contain 30 cubic feet, or about 224 gallons of gas—as much as would *fill* 6 *of the large* 30 *by* 40 *inch gas-bags* commonly employed.

Two of these reservoirs, one charged with oxygen and one with burning gas, can be easily carried by a boy, and represent in efficiency a large cart-load of apparatus on the old plan, namely, 12 gas-bags, 2 sets of press-boards, and some 600 pounds in iron weights.

These reservoirs may be directly connected with the jet, which must be then regulated by the plug-valves attached to the reservoirs.

The same inventor, however, supplies a regulator, which you here see attached to this reservoir, which equalizes the pressure beyond it, so that the gases may be controlled or shut off from the light without danger of bursting the connecting india rubber tubes.

While the pressure in the reservoir is at about 30 atmospheres you see by this water-gauge that, beyond the regulator, it amounts only to 12 inches of water, or the $\frac{1}{30}$th of an atmosphere, and is little changed by altering the flow of gas at the jet or shutting it off entirely.

These reservoirs are furnished at a price regulated by their capacity in the sense of strength, (since all are of one size,) this being one dollar per cubic foot. Thus a reservoir capable of bearing a pressure of 30 atmospheres, and therefore of holding 30 cubic feet, costs $30, one bearing 20 atmospheres, and therefore holding 20 cubic feet, $20, &c.

The gases are supplied at the rate of 30 cents for oxygen and 3 cents for burning gas per cubic foot, charged into the reservoirs.

In the case of oxygen this is about double the cost of the chlorate of potash needed to make it.

In reservoirs of similar form, but of stronger construction, nitrous oxide and carbonic acid are furnished in the liquid form. Thus, at a lecture delivered last Spring in the Brooklyn Academy of Music, by Dr. Doremus, Mr. Grant supplied 40 cubic feet of liquid carbonic acid for certain of the experiments.

The next point of improvement is in the form of the jet at which the mixed gases are burned. This is made by hammering in the end of a tapering copper tube, and then boring a hole in the flattened end, so that the vertical section of the jet shall be as is represented in the cut.

The different gases enter this tube at its lower end and are lit where they escape from the upper end. By the simple means above indicated all snapping of the jet from the running back of the flame into it, and consequent extinction of the light, are avoided, even when jets of extraordinary size are employed. Large jets, in fact, cannot be operated with the mixed gases except in this way, while with this form jets have been used of immense size. Thus, at the lecture before mentioned, a *cavalry sabre was burned up* in one of these.

The reason of the efficiency attained by this form seems to be, that while in a simple cylindrical or conical jet, the friction against the sides establishes a rolling motion in the gas particles, whereby the velocity of the issuing jet is diminished at its surface, thus allowing the fire to run back and ignite the mixture inside; in this case all such action is prevented, and the maximum velocity is maintained in all parts of the issuing stream.

It has been pointed out by Tyndall that the non-explosion of the gases in the jet, is simply secured by forcing them out faster than the flame will run back, and the plan now before you is an illustration of this theory. Important improvements often demand a bold departure from received methods, and it is curious to notice in the present case that what has been previously sought by the use of many narrow passages, wire gauze diaphragms and other like means, is here attained by discarding them all. By the use of jets constructed on this plan, which may be of a size heretofore unattainable, and reservoirs such as above described of very unusual practical capacity, an amount of light is generated so great as to open new fields for its application, and to enable it, for many purposes, to take the place of the electric light in fields where heretofore this last defied competition. Such applications are the lighting of large areas for public assemblies in the open air, either for purposes of debate or amusement; the illumination of extensive engineering structures during night-work, especially in connexion with the repair of railroads, bridges, &c., where delay involves interruption of traffic and great consequent loss; lastly, various applications in connexion with military affairs. No better means can be taken to give a clear impression of the efficiency of these lights in all

the above uses, to which they have been successfully applied, than a description of their operation during the siege of Fort Wagner on James' Island, opposite Charleston, where they were employed with the happiest effect.

The front of Fort Wagner, toward which the advances of the United States forces were made, was about 700 yards in length, while the approaching saps were confined to a narrow strip of solid land about 50 yards across, the rest of the fort being covered by a swamp on one side and the ocean on the other. For this reason, when the head of the sap had been pushed to within 250 yards of the fort, further advance was rendered impossible, because the zig-zags would be enfiladed from one side or another by the guns at the extremities of the fort.

It was under these conditions, no advance having been made for several days, and the loss in the trenches being very heavy, that the calcium lights were first tried. Two of these, with jets $\frac{1}{18}$ inch in diameter, burning about 14 cubic feet of gas per hour, were set up at the extreme left of the second parallel, about 750 yards distant from the fort. These jets were supplied from large reservoirs 15 inches by 8 feet, each capable of holding 250 cubic feet. Both the gases were made on the island in a laboratory established for the purpose, where a detail of 20 soldiers and 12 negroes was constantly employed in the manufacture and compression of the gases for use in various ways connected with the military operations at this point, such as the prevention of blockade running at night, of sending supplies and troops to Fort Sumpter, &c.

The two lights above mentioned were so arranged with parabolic mirrors as to throw sectors of light, one over one half of the fort and the other over the remainder, the field of light being sharply cut by a diaphragm so as not to reach below the edge of the parapet. The effect of this was to make every motion, and each figure on the rebel works, perfectly clear to those in the trenches, while the space below, from the ditch of the fort to the saps and parallels, was hid in impenetrable darkness.

The Union riflemen and sharp-shooters, in fact, were able to leave the protection of their works with impunity, while, on the contrary, all the gunners in the fort were exposed to a deadly fire. The consequence was that, within twenty minutes after starting the lights, the fort, from which a constant fusilade had been kept up ever since the darkness set in, was *absolutely silenced*, and remained so during the night.

Advantage was, of course, taken of this condition to push forward the sap, and by the end of the second night such progress had been made that the eastern angle of the fort was entered, and the work becoming no longer tenable, was abandoned by its garrison. Of course, every available gun was brought to bear upon the lights from the neighboring batteries, but their dazzling points seem to have been very hard objects to aim at, for though some of the reservoirs were hit by fragments of shell, and still bear the dints so inflicted, the apparatus was never seriously damaged.

Lime-lights for locomotives.—In connexion with the above we will here note the fact that many locomotives on the Pennsylvania Central Railroad have, during the past year, been using in their front lamps an apparatus in which light is obtained by driving a jet of gas, carried in one of these reservoirs, mixed with air supplied by a small pump worked by the engine and heated in a small coil of tube passing over some minute burners before it issues from the jet. We are not yet informed of the details and precise results of this process, but hope to supply full information by the next meeting of this Institute.

In the *London Mechanics' Magazine*, for June 8th, we find an editorial on the subject of car lighting, in which it is stated that the process of lighting with gas, carried in flexible bags, has been found very inconvenient and unsatisfactory in its results, and that some of the larger companies have therefore made experiments on the practicability of using iron reservoirs and storing the gas under pressure. These, it appears, have culminated in a plan by Mr. Wm. Dalzeil, who uses iron cylinders of 18 inches diameter by 9 feet 6 inches in length, and pumps in the gas up to a pressure of 120 pounds per square inch, or eight atmospheres.

To those who, for the last eight years, have been riding between this city and New York, not to mention most of our other large roads, in cars lit in exactly this way, it will seem that some kind friend might have saved these companies the expense of preliminary experiments.

A new form of magnesium lamp has been invented and applied by Mr. H. Larkin, and was exhibited at the late meeting of the British Association, when two of these lamps were employed to light a large tent, which had been decorated with flowers, shrubs, rockwork, fountains, &c.

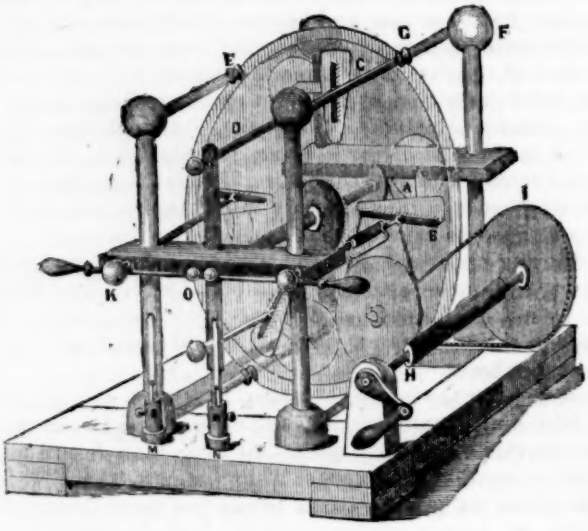
In this apparatus the magnesium is employed in the form of a fine powder in place of wire or ribbon, as in previous instruments. This powder is mingled with a little fine sand to facilitate its flow, and is then fed from a hopper, through a regulating-valve, into a tube or nozzle to which is admitted a current of burning-gas, so that the powder escapes from the end mingled with enough gas to keep up a small flame. This gas jet may be first lit and allowed to burn, and then the magnesium turned on and off whenever convenient. The addition of a little nitrate of strontium to the powder is said to relieve the painful blueness of the pure magnesium light.

Micro-photography.—Under the present head we would call attention to the very interesting papers on the above subject by Major J. J. Woodward in the September number of the *Philadelphia Photographer* and *Silliman's Journal*. On a future occasion I hope, however, to exhibit to you, in an advantageous manner, specimens of the work produced by this gentleman, which, as you are probably aware, introduces a new era in this branch of scientific application.

PHYSICS, Electricity.—The Holtz electrical machine was then exhibited and described. This is of great interest, both on account of its entire novelty (the instrument in question being the first seen in this country, and even the first of large size manufactured in Paris,)

and by reason of the new applications of electrical facts which it involves, and lastly by reason of its very great efficiency.

The action of this machine will be best understood if we first describe fully the accompanying cut which represents it.



The most conspicuous part of this instrument is its pair of glass plates. These are arranged in close proximity to each other, and are both made of very thin plate-glass varnished with shellac. The nearest of these plates, as shown in the cut, is a little the smaller and is perfectly plain, supported on an axle which passes through a large central hole in the other plate and is put in motion by a winch H and pully wheels I, &c. The further and larger plate is supported in the grooved balls E, G, &c., on the horizontal glass rods, and has, beside the central hole, four others, of a circular shape, as indicated in the cut. At one side of each opening is pasted a strip of paper with a point of card projecting into the opening. The rotation of the movable plate is in a direction from point to base of these card projections. Opposite to each of the paper strips, but with the revolving plate, (be it remembered,) between, is a brass comb or collector B, C, &c., supported in the cross-piece of vulcanite K D by appropriate brass rods, having balls at their opposite ends. Sliding-rods passing through two of these balls enable us to vary the distance of the poles and so to modify the discharge. Sliding brass conductors, M N, may be brought in contact with these poles, and so, by the binding screws at their base, enable us to make connexion with various pieces of apparatus.

One of the brass rods is separated by a portion of vulcanite, but may be united electrically by a wire staple, as shown in the cut near B.

The four brass collectors may be united in various ways by bent

wires for different effects, but we will at present only describe one of these.

The conductor B being insulated by the removal of the wire staple, is connected with the opposite one by a bent wire, and thus the ball to the left becomes the pole for these two.

The upper and lower balls are in turn united by a wire which rests on the right-hand ball, through which the sliding rod passes, and this thus becomes the pole for this pair of conductors.

The movable plate being started in rŏtation by the winch and pulley-wheel, one of the paper strips is charged by touching it with a piece of vulcanite, excited by a stroke over a rabbit skin, and at once the whole machine is in activity, giving sparks of great volume and intensity, which may be continued for an indefinite time without further charging.

There are no rubbing parts in the machine, the whole effect being developed by induction or the disturbance produced in the electric fluids by the repulsion of like and attraction of unlike kinds. And yet, strange to say, this friction-avoiding machine exhibits all the effects belonging to what is commonly called frictional electricity.

It will pour a torrent of sparks between its terminal balls too rapidly to admit of their being counted and each giving a report like that of a torpedo; or, by a different adjustment, will furnish a continuous jet of electric fire, seeming to pass without change or pause in a tassel of purple light trimmed with golden beads and emitting a hissing sound like that of escaping steam. Those beautiful instruments, the Geissler tubes, are operated by this machine with the most excellent effect. The theory of this machine seems to be as follows: Suppose one of the paper strips, C, to be negatively excited by contact with the vulcanite, it will draw positive electricity from the opposite brass conductor, D, and cause this fluid to spread over the nearer side of the movable plate. The plate then turning in the direction C A, before mentioned, this positively charged portion will come opposite the next opening in the fixed plate, and the repulsive action of the positive charge, just mentioned, will cause other positive fluid to be repelled from the further side of the revolving plate and to enter the point projecting from the paper, A, at that part, so charging this strip positively.

This positively charged strip of paper will then act upon the revolving disk exactly as the negatively charged one did before, but, of course, in the opposite sense, *i. e.*, it will attract negative electricity from the conductor B, and excite negatively the outer side of the revolving plate as it passes this point, by which means negative electricity will be carried to the next strip of paper, and so on alternately around the plate.

This whole description might, of course, be duplicated in the sense of stating in every case, where positive fluid goes one way, that negative goes in the opposite, and *vice versa*, but this would simply confuse the explanation without in any way effecting its bearing.

To obtain condensed and bright sparks, we attach a glass tube, closed at one end and lined internally with tin-foil, so that its lining is in connexion with one of the brass conductors.

Printing Telegraph.—We see announced in the *London Mechan-*

ics' Magazine for July, page 21, some improvements in the Bonelli telegraph, by which the number of wires needed was reduced from five to one. This telegraph transmits its messages from type which are set up and passed under a metallic point, by which a current is transmitted and a fac-simile produced at the distant place by electric decomposition in a strip of prepared paper.

In a subsequent number of the same magazine, page 59, these improvements are claimed by Mr. J. H. Simpson. The great drawback in the use of all these electro-chemical telegraphs has been the cost of batteries needed to work them, and we do not see that either of the plans will reduce this within the required limits.

Mr. Wild's improvements in magneto-electric machines have been purchased by the Alliance Company of France, and we may therefore soon hope to see them practically applied, and the cost of these instruments so reduced as to render their general use and application possible.

CHEMISTRY.—A test for gilt articles, to distinguish them from those which are simply made of a gold colored bronze, is announced by Weber. It consists in the application of bichloride (the common chloride) of copper in solution, which makes a brown stain on other articles but does not affect those which are gilt. This statement I have verified with articles known to be gilt and with several varieties of gold colored alloys.

The oxidation of crude soda liquors may be effected in a rapid and economical manner, according to a plan proposed by James Hargraves, if the solution to be treated be placed in an iron cylinder having a false bottom, pierced with many holes, into the space beneath which runs a vertical tube expanded at its upper end into a funnel. Into this funnel, high pressure steam is run by a pipe, and this carries down a large quantity of air below the false bottom, and this air, heated by, and in presence of, the steam, exerts a powerful oxidizing action as it rises through the liquid in numerous bubbles from the perforation of the false bottom.

A new water purifier is manufactured of Ransome's artificial stone. Two concentric vessels are constructed of this porous material, and, the space between them being filled with animal charcoal or other similar matter, the whole apparatus is set in a tub or tank of water which then percolates into the interior vessel from which it may be drawn in any one of several simple ways.

A new process for the manufacture of chrome salts, by the treatment of chromate of lime, (which is obtained directly from the ore,) with sulphurous acid, is announced by M. J. H. Chaudet, of Rouen. The SO_2 produced by combustion of sulphur is forced through the solution of chromate, when the lime is precipitated as sulphate, and the chromic acid reduced to a basic condition.

An excellent bone manure may be prepared, according to the Russian chemist, Illienkof, by mingling in a trench or reservoir 40 parts of ground bones, 40 parts of wood ashes, and 6 parts of quicklime, with water enough to moisten the whole, and allowing the mixture to remain some days.

Magnesium, as we learn from a paper by M. Roussin, precipitates a large number of metals from their solutions. Thus the following are thrown down as metallic powders by this body: Au, Ag, Pt, Bi, St, Hg, Cu, Pb, Cd, Tl, Fe, Tyn, Co, Ni; the elements Cr and Mn are, however, precipitated as oxides.

A remarkable fall in temperature by solution of other metals in mercury is announced by Dr. Phipson. He says that 207 parts of lead, 118 parts of tin, and 284 parts of bismuth being mixed with 1617 parts of mercury, the temperature will fall from 62°.6 to 14° F.

Gutta-percha cement is made by dissolving that body in chloroform, so as to produce a honey-like fluid. This is spread upon the articles to be secured, and allowed to dry. The pieces are then warmed until the coating softens, and are pressed together. Patches of leather may be thus put upon boots in a manner which defies equally detection and dampness.

Lemons may be preserved by coating them with a varnish of shellac dissolved in alcohol. When used the lemons are rolled and washed in water.

Sugar, it has been stated, may be made from benzole by a process lately discovered by Casius.

A curious experiment in elementary mechanics, illustrating various important laws, devised by Samuel Alsop, was lately brought to my notice by Professor A. R. Leeds, and I cannot better close my report than with this new and curious illustration.

A cord, as you perceive, is tightly stretched across the entrance of this alcove, being about twenty feet in length, and from this are hung, at equal distances in each case from the adjacent end of the cords, two equal pendulums, *i. e.*, equal strings with equal weights attached.

We now set one of these vibrating transversly to the sustaining cord. In a few moments we see that the other pendulum is beginning to swing, and that, as the motion of this second one increases, that of the first is lost, until the first comes absolutely to rest and all the motion has been transferred to the second. As soon as this condition has been reached the action is reversed, the second pendulum now giving up its motion to the first, until the second comes to rest and the first swings through a large arc. This alternation and transfer will, in fact, continue until the resistance of the air has brought the whole system to rest.

This action, though curious, and at first sight mysterious, is easy of explanation. The pendulum first started tends to set the other in motion by slight deflections of the supporting cord in a horizontal direction, but the vibration thus established in the second pendulum is of necessity (and as you easily perceive by observation) a little behind that of the first, and this relation once established is maintained throughout on account of the equality and consequent synchronism of the pendulums, so that however short the arc traversed by the first, and however long that of the second, the former is always a little ahead of the latter, and is thus dragging it on, or, in other words, giving up its own motion to it until the very last.

When, however, the first pendulum has at length come to rest, exactly the same process of transfer goes on from the moving to the stationary pendulum, as we have just described.

This experiment may be indefinitely varied by increasing the number of pendulums, and changing their directions of vibration, or weights, and is most instructive in all its forms.

Upon the conclusion of the Secretary's Report the meeting was, on motion, adjourned.

HENRY MORTON, Secretary.

BIBLIOGRAPHICAL NOTICE.

Chemical Tables. By STEPHEN P. SHARPLES, S.B. Cambridge: Sever & Francis, 1866. 12 mo., pages 192.

This very useful little volume was undertaken at the suggestion of Prof. Wolcott Gibbs of Harvard College, and executed under his immediate supervision. The high reputation of Prof. Gibbs as a physicist and analytical chemist is of itself a sufficient voucher for the judicious selection and accuracy of the tables. The student of physical science will find here collected tables of the equivalents, specific gravities, dilatations, specific heats, solubilities, in short, all the leading characteristic properties of the bodies generally met with, whether simple or compound. The factors and formulas for calculating analyses, and physical problems and experiments, are here ready at hand; and the work concludes with tables of French weights and measures, and their comparison with English, and a table of logarithms. The formulas relating to light are particularly interesting in reference to the rapidly improving methods of qualitative analysis by optical observations. Great judgment is required in selecting among the number of experiments which have been made and formulas which have been given, for many of the objects embraced in this volume; and where it was possible the authors have given the results of two or three of the most reliable observations. Where this was not possible without extending the work to unmanageable size, different physicists may, of course, differ in their opinion of the relative value of different observers, but we think that all will agree that Prof. Gibb's selection has been made with great care, and without prejudice or favoritism. We know of no book in the English language where the valuable information here contained is collected together, and we look upon it as indispensable to every one engaged in physical or chemical research, or in the application of science to the arts. We hope soon to hear that a second edition has been called for, and, in view of the recent acts of Congress, in reference to weights and measures, suggest to the authors some tables of the transformation of French into English, as well as English into French units. It is hardly necessary to say that, coming from the press of Sever & Francis, the mechanical execution of the book is everything that could be desired.

A Comparison of some of the Meteorological Phenomena of AUGUST, 1866, *with those of* AUGUST, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	August, 1866.	August, 1865.	August, for 16 years.
Thermometer—Highest—degree, .	88·00°	91·00°	97·00°
" date, .	1st & 2d.	3d & 4th.	2, '56; 4, '59.
Warmest day—mean,	81·50	84·50	88·50
" " date,	2d.	4th.	10th, '63.
Lowest—degree, .	57·00	58·00	47·00
" date, .	24th.	23d.	26th, '56.
Coldest day—mean,	62·00	64·17	59·00
" " date. .	23d.	23d.	26th, '56.
Mean daily oscillation,	14·03	12·13	15·42
" " range, .	3 77	3·29	3·69
Means at 7 A. M., .	67·82	72·10	70·84
" 2 P. M., .	78·36	81 02	81·18
" 9 P. M., .	71·32	74·56	73·89
" for the month,	72·50	75·89	75·30
Barometer—Highest—inches, .	29·957 ins.	30·141 ins.	30·255 ins.
" date, . .	17th.	1st.	20th, '55.
Greatest mean daily press.	29·935	30·127	30·229
" " date, .	12th.	1st.	20 & 31, '55.
Lowest—inches, . .	29·376	29·540	29·356
" date, . .	9th.	22d.	20th, '56.
Least mean daily press.,	29·459	29·557	29·388
" " date, .	9th.	22d.	20th, '56.
Mean daily range, .	0·096	0·089	0·094
Means at 7 A. M., .	29 750	29·847	29·858
" 2 P. M., .	29·711	29·814	29·839
" 9 P. M., .	29·751	29·847	29·851
" for the month, .	29·737	29·836	29·846
Force of Vapor—Greatest—inches,	0·818 in.	0·890 in.	1·024 in.
" date, .	9th.	5th.	1st, '54.
Least—inches, .	·351	·294	·268
" date, .	17th.	24th.	often.
Means at 7 A. M., .	·522	·575	·583
" 2 P. M., .	·547	·596	·591
" 9 P. M., .	·568	·596	·611
" for the month,	·546	·589	·595
Relative Humidity—Greatest—per ct.,	95·0 per ct.	85·0 per ct.	100·0 per ct.
" date,	13th & 14th.	22d.	26th, '54.
Least—per ct.,	42·0	41·0	27·0
" date, .	18th.	24th.	1st, '60.
Means at 7 A. M.,	75·4	71·4	76·1
" 2 P. M.,	56·7	55·3	56·0
" 9 P. M.,	73·7	69·1	72·7
" for the month	68·6	65·3	68·3
Clouds—Number of clear days,* .	10	8	9·5
" cloudy days, .	21	23	21·5
Means of sky cov'd at 7 A. M.,	52·9 per ct.	61·3 per ct.	55·9 per ct.
" " " 2 P. M.,	59·7	66·1	61·2
" " " 9 P. M.,	36·1	25·5	41·5
" " for the month	49·6	61·0	52·9
Rain—Amount, ...	2·567 ins.	2·993 ins.	3·750 ins.
No. of days on which rain fell, .	12	6	9·7
Prevailing Winds—Times in 1000,	s86° 56′ w ·336	s74° 13′ w ·270	s77° 26′ w ·129

* Sky one-third or less covered at the hours of observation.